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Especially to *the* Natural
History *of* Ohio.

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THE REDUCTION DIVISION IN FUCHSIA*.

Blanche McAvoy.

The genus Oenothera has been of great interest in recent years to biologists because of DeVries' studies on Oenothera lamarckiana in connection with his development of the mutation theory. A number of investigators have worked on Oenothera among whom may be mentioned Lutz (13 & 14), Geertz (10), Gates (5, 6, 7, 8 & 9), and Davis (2 & 3).

Some of the investigators have worked on the cytology of the micro- and mega-sporocytes while others have worked on the genus from a somewhat different point of veiw, getting the complete life history as a basis for evidence of the validity of DeVries' results.

Geertz (10) has made a complete study of Oenothera lamarckiana beginning with the archesporial cell, taking up the cytology and continuing on through the details of the complete life history. In some of the microsporocytes he describes threads with small chromatin discs on them, some of the threads being quite small and others thicker. He calls the early contraction generally observed in prepared sporocytes synapsis and says that in some cases there were loops extending out from the contracted mass. The material may be contracted around the nucleolus or may be separated from it. Immediately after synizesis he represents fully formed chromosomes in the nuclear cavity. He says that the 2x number of chromosomes were formed and later

*Contribution from the Botanical Laboratory of Ohio State University, No. 69.

united in pairs. He did not find a conjugation of two threads during synapsis. He mentions a slight resting stage between the first or heterotypic division and the second, homotypic division, but does not speak of any longitudinal splitting of the heterotypic chromosomes until after the transverse splitting occurs. The longitudinal splitting was visible just before the chromosomes reached the poles.

Gates (7) in his paper on Oenothera rubrinervis, states that the contraction of the chromatin material is synapsis and that since the cytoplasm of the cells shows no contraction, the cell is perfectly fixed. For this reason, the contraction, so constantly observed at an early stage in the process, is not an artifact, but is a real contraction stage, leading to synapsis. As this contraction proceeds the reticulm is re-arranged into a long, continuous delicate thread. No indication of a doubling or pairing of the threads was evident. After the synapsis the spirem shortens and thickens and begins to arrange itself more loosely in the nuclear cavity. This shortening is progressive and continues for some time. He states that the shortening may be uniform, or it may vary or may be irregularly constricted at varying intervals. This thickened thread now segments transversely into fourteen chromosomes—fourteen being the sporophytic number. Then these chromosomes break up into pairs which later fuse with each other leaving the x number of chromosomes. They are taken on the spindle and reduction follows in the usual way.

In his paper on Oenothera lata x O. gigas (9) he begins his dicussion with the telophase The usual number of chromosomes found in the hybrid is twenty-one, seven being of maternal and fourteen of paternal origin. In the reduction one germ cell receives ten and the other eleven chromosomes. In a few cases nine and twelve chromosomes were the numbers found at the respective poles. One cell was found which had twenty chromosomes, ten of which went to each pole. The segmentation into ten and eleven proves that there is not a pairing of homologus chromosomes of maternal and paternal origin but the segmentation tends to be into two numerically equal parts. Gates claims evidence from his work, that there are two general methods of chromosome reduction, one a side to side pairing of chromatin threads (parasynapsis) to form a double spirem; the other involving an end to end arrangement (telosynapsis) of maternal and paternal chromosomes, to form a single spirem which afterwards splits longitudinally. He says an individual always has as many chromosomes as the sum of the chromosomes in the germ cells which go to form the new plant. This fact, he says, supports the genetic continuity of the chromosomes. He has not shown whether the chromosomes have equal or unequal hereditary value.

In his paper on Oenothera lata x O. lamarckiana (5) he finds starch grains present in the cytoplasm of the mother cell. These grains become more abundant until the reduction takes place after which they are not found. He finds what he calls "prochromosomes", but in a later paper considers these bodies to be nucleoli. The presynaptic stages show a continuous spirem which is exceedingly delicate and coiled. Then follows the contraction, after which follows a stage in which the spirem is much shortened and several times thicker than just before the contraction. He does not believe that the nucleoli break up and move out into the cytoplasm waiting to be re-collected into a new nucleolus in the new nucleus, as Schaffner believes to be the case in Lilium philadelphicum. There are twelve chromosomes and one or two "heterochromosomes", or as he calls them in a later paper—nucleoli. He believes O. lamarckiana to be a pure strain and not a hybrid.

In the paper on Oenothera gigas (8) Gates says "The absence or partial absence of a close pairing of chromosomes in diakinesis and on the heterotyptic spindle is in strong contrast to the condition in other genera of plants where the chromosomes are regularly paired. However * * * similar failure to pair is often exhibited. These cases appear to be the exceptions to the general law enunciated by Montgomery in 1901 from his observations on Hemiptera, that homologous chromosomes of maternal and paternal origin pair with each other in synapsis. Later observations on a variety of forms, in which there are morphological chromosome differences, show that ordinarily chromosomes of similar size and shape pair with each other and justify the view of Montgomery which has been widely adopted. There is some variety in the size and shape of the chromosomes but nothing constant was observed." In the anaphase the longitudinal split generally described does not always show. There are some irregularities in the reduction such as an unequal number of chromosomes passing to the two poles.

Davis in his first paper on Oenothera (2) observes the nucleus filled with a close reticulum having the chromatin material distributed around the periphery of the nucleus. Next follows the appearance of extremely delicate strands connecting the bodies, forming an open net work. These strands readily thicken and become more numerous until finally the nucleus is filled with a relatively close reticulum. During this time the chromatin bodies become smaller and seem to contribute their material to formation of the strands so that the only large structures in the nuclei are the nucleoli. Synapsis, as he calls the synizetic contraction, begins slowly and finally carries the strands away from the nuclear wall. During this contraction there is a marked change in the structure of the reticulum At first the reticulum

was connected at many points but in time it is easily seen that a true spirem is being formed. During the main part of the contraction the knot is so close that it is difficult to see any of the structure. Usually there are threads sticking out at the edge of the knot. During the process the thread of the spirem is shortened. He thinks the contraction is due to this shortening of the threads of the reticulum as it goes to make up the spirem. The forms of the "synaptic" knot are varied. When the knot loosens the chromatin material is seen to be in the form of seven bivalent chromosomes, which have assumed the form of rings some being linked together. These rings, he says, remain together until the two halves of the bivalent rings are pulled apart on the spindle.

In the second paper(3) he states definitely that he believes the dark staining masses formed on the perifery of nucleus and connected with one another by delicate threads to be the "prochromosomes" described by Overton (17) but he says there is no evidence that they are arranged side by side in pairs on a system of threads that might be interpreted as two parallel spirems. The chromatin bodies are scattered throughout the nucleus but where ever there are two together they lie end to end upon a delicate strand that runs in the direction of the longer axes. The nucleus after considerable time, becomes filled with a close reticulum at which stage the chromatin bodies can only be distinguished with difficulty. He found some differences in the method of chromosome formation from that described in his first paper. The knot loosens and a shorter thicker thread emerges. This spirem is then constricted into a chain of fourteen chromosomes. A longitudinal split becomes apparent just before the heterotypic chromosomes reach the poles.

In Erythronium, Schaffner (19) finds the chromatin material going into synizesis—a term used to designate the contraction as being a separate thing from the fusion of the chromatin. This contraction he considers to be an artifact. After synizesis he finds the formation of a spirem which by twisting, forms loops all around the nuclear wall. There then occur breaks between the loops. The loops continue to twist until the chromosomes are fully formed. The chromosomes are described as having quite distinctive shapes.

In Lilium tigrinum (20) he found a continuous spirem with a single row of chromatin granules. This spirem enters synizesis and comes out of it without a conjugation or a division of granules. Later on the granules divide but the linen thread does not show a distinct separation. The continuous spirem shortens, thickens, and twists into twelve loops which break into twelve chromosomes. These chromosomes are attached to the spindle fibres in the mother star at or near the end and during the reduction the chromosomes uncoil and separate by a transverse division at the

middle. The next division is longitudinal and the resulting nuclei form the tetrads. The nucleoli fragment and pass into the cytoplasm during both the first and second divisions.

In Agave viriginica (22) Schaffner described bivalent protochromosomes which formed a long delicate continuous spirem with a single row of chromatin granules. Synizesis follows during which there is no union of the spirems. A study of living material did not show any noticeable contraction of the nuclear contents and the nucleoli were usually found occupying a central position in the nucleus. While the chromatin granules undergo transverse division, the spirem shortens and thickens and then twists up into twelve loops of different size and shape which are pressed against the nuclear wall. These loops then break apart into four large, three ring shaped and five small irregular chromosomes. One or two nucleoli are present which may be thrown out into the cytoplasm. The spindle is bipolar and at the first division the chromosomes divide transversely but the second division is longitudinal.

Miss Hyde in her paper on Hyacinthus (11) did not find definite protochromosomes nor a splitting of the spirem. She observed a continuous spirem which formed eight definite loops. These loops break apart and form eight chromosomes of different characteristic sizes and shapes.

There has been much controversy as to the real nature of the contraction generally observed in the early stages of the division of reduction cells. In most cases this contraction is accompanied by an enlargement of the nucleus due to the expansion of the nuclear wall. McClung (15) has suggested the term synizesis, to be used to mean the contraction as distinct from synapsis, synapsis being restricted to the fusion of simple chromosomes into multiple ones. Lawson (12) has recently investigated the problem and his interpretation of synizesis is simply that it represents a growth period of the nucleus—a period during which there is a great increase in the amount of nuclear sap, which results in a distention and withdrawal of the nuclear membrane from the chromatin. As to why the nucleus should swell so much immediately before the reduction division he answers as follows. Each cell is charged with sufficient food substance for the production of the tetrad. Moreover there are two divisions which follow one another in quick succession. The pressure of the cell sap acting from within causes the nuclear membrane to distend and the nuclear cavity to expand. The expansion is at first gradual and continuous until the nuclear cavity grows to twice or even three times its original size.

As the growth proceeds the membrane is gradually withdrawn from the chromatin mass within. The result of this withdrawal of the nuclear membrane is the formation of a large clear area of

nuclear sap containing the mass of chromatin which has been left to one side. No evidence whatever was found to show that any contraction of the chromatin had taken place. The enlargement of the nuclear cavity and the consequent withdrawal of the membrane away from the chromatin gives the appearance of a contraction, but actual measurements failed to show any diminution in chromatin area.

During this stage definite changes take place in the nature of the chromatin threads as the spirem becomes differentiated.

This view is somewhat similar to that expressed by Schaffner in Synapsis and Synizesis (21) although he believes that synizesis is a true shrinking of chromatin material due to the effect of the killing fluid on the nuclear contents, which has become loosened from the nuclear wall on account of the swelling of the nucleus. One important proof for this conclusion was the fact that in many instances there are symmetrical contractions showing the same peculiarities as in ordinary plasmolysis. On the other hand Gates and Davis whom I have quoted above believe this stage to be natural and do not believe it to be an artifact. They base their opinion on the fact that the contraction is of such constant occurrence in all forms studied.

Because of the apparently peculiar process of chromosome formation reported for the Oenotheras differing somewhat from both the type of division held by Allen and others on the one hand and by Schaffner and others on the other, it seemed desirable to the writer to investigate the formation of the chromosomes in Fuchsia. Accordingly a study of the reduction division in the microsporocytes of Fuchsia was taken up under the direction of Professor John H. Schaffner, whose help and kindly criticisms have been of inestimable value throughout the whole year's work.

When starting the problem I expected to find the chromosomes formed in the manner described by Gates for Oenothera rubrinerves and by Davis for Oenothera biennis. The most of my attention was directed toward finding how the chromosomes were formed. I wished to see whether it was by the thickening of the spirem followed by a transverse division by which the 2x number of chromosomes were differentiated and then cut off in pairs, which should afterward fold together to form the bivalents; or whether the spirem thickened and then folded and twisted around into the number of loops before a subsequent separation into the reduced number of chromosomes. These two methods are very similar in results but somewhat different in detail. Gates found the chromosomes formed in the first way described and since Fuchsia is not so distantly related to Oenothera, it was natural to expect to see the chromosome formation brought about in much the same way that Gates found in Oenothera.

Two varieties of the Fuchsia commonly grown in greenhouses were used. Both were varieties of Fuchsia speciosa (Hort.), of rather small size—one variety having red and the other white sepals. The species is commonly supposed to be a hybrid. Fuchsia speciosa was obtained from the greenhouse in connection with the Botany building of the Ohio State University at Columbus The buds which showed the reduction stages were quite small, being about 3-5 mm. in length. They were killed in Schaffner's weaker chrom-acetic solution. Material was left in the killing fluid for 24 hours and then thoroughly washed and run up to 70 per cent alcohol where it was left for several days. Then 85, 95 and 100 per cent alcohols were added in turn and chloroform and from that the buds were slowly taken into pure parafin and imbedded. Sections were 10–15 mic. thick. Delafield's Haemotoxylin was tried with poor success. The best stain was a combination of Safranin and Iron Haemotoxylin. The slides were transferred from 25 per cent alcohol to Safranin and left for four hours. They were then washed off in 25 per cent alcohol and put into water and then transferred to iron alum. Slides were kept in iron alum for four hours and then washed for a while in water, after which which they were left over night in Haemotoxylin. Next day the slides were bleached in iron alum, and in some cases acid alcohol, and were mounted in balsam.

The tapetal layer is rather slow in developing but by the time the sporocytes began to be differentiated it can easliy be distinguished as a limiting layer of the sporogenous tissue. The sporogenous tissue remains intact during all the early stages of the reduction process and it is only while the chromosomes are being formed that the sporocytes become separated from each other and from the tapetal wall. In cross section the stamens show the usual four microsporangia and each cavity usually contains from five to eight sporocytes. As the stamen grows older the number of sporocytes, that show in cross section decreases until four is the more usual number. This may be due to the rapid elongation of the anther at the time when the sporocytes are separating.

The nucleus in the early stages is rather small and is made up of a reticulum, containing dark staining masses (Fig. 1). As the nucleus enlarges these lumps become much more prominent and definite and may be regarded as protochromosomes (Figs. 2, 3, 4). In no case was it possible to make a positive count of these masses since some of them had apparently begun to disintegrate while others were just forming. As the lumps disappear the material seems to go toward the formation of small chromatin granules which are scattered along a delicate thread (Figs. 4, 5, 6). This thread could be traced for some distance in a number of the cells. Often there are two nucleoli present in one nucleus but in most

cases there is only one. There is no difficulty in distinguishing the nucleoli from chromatin material since the safranin used in the combination stain gives the nucleoli a peculiar reddish tinge while chromatin material stains nearly black The nucleolus is in the middle of the nucleus, sometimes a little to one side; and on the periphery of the nucleus is the network and chromatin granules spoken of above. A little later the nucleus begins to swell very considerably, and gradually the network is loosened in one place or another from the nuclear wall. At this time the nucleolus is still in the middle of the nucleus. As the process continues the nucleus becomes larger and more of the threads becomes loosened from the wall (Figs. 6. 7. 8).

At this stage the synizesis begins, the spirem massing together into an irregular lump which may or may not enclose the nucleolus. In some cases the nucleolus may be entirely separate from the synizetic knot. No division of the granules or longitudinal split of the spirem was observed. There is a well defined thread now present and in some cases loops of the thread could be seen sticking out from the opaque knot (Figs. 9 and 11). In other places little apparently free ends of the thread projected from the mass. On these threads definite chromatin granules were plainly visible and could easily be counted in any free loop. Whether the free ends represented natural breaks in the spirem or injuries caused by the contraction or the cutting, could of course, not be determined. But the appearance of the spirem before and after the synizesis indicates that the spirem is continuous. The contracted chromatin mass was sometimes formed to one side of the nuclear cavity and sometimes in the middle (Figs. 9, 17). Sometimes it extended across the nucleus. There were various stages of contraction from the loosely coiled mass in which the threads were clearly visible (Fig. 11) to the tightly contracted mass in which no structure, whatsoever, could be made out. During older stages of the synizesis the knot is very much looser and the thread is much more complete and is thicker with the granules of a more uniform size. There is no question but that there has been a contraction of the chormatin, the mass occupying a much smaller area than before, while the nuclear cavity is much larger. Whether some of the enlargement of the nuclear cavity was due to plasmolizing reagents or entirely due to a normal growth could not be determined since there is considerable difference in the size of various nuclei of apparently the same stage of development.

Immediately after the synizesis the threads are delicate and contain numerous small granules. It is exceedingly difficult to follow the thread through all its convolution but in some cases it could be traced for quite a long distance (Figs, 12, 13, 14). There is generally one nucleolus at this stage but in some cases two are

to be seen. As division advances the thread continues to elongate up to a certain stage when it is rapidly thrown into loops (Figs. 12, 13, 14), and begins to shorten and thicken constantly until the chromosomes are fully formed (Figs. 13, 15, 17, 21, 22). In the very earliest stages of the looping (Figs. 13, 14, 15, 16) the spirem may be traced for a long distance and the loops are found on the upper and lower surface of the nuclear wall showing that the loops are formed along the periphery of the nucleus and not as loops sticking out from a synaptic knot into the nuclear cavity.

However, in the earlier stages there is a considerable crossing of threads in the center. Figure 13 shows four or more well defined loops already formed. These loops and the thread of which they are formed are still rather delicate. The nucleolus is in the center of the nuclear cavity. In some cases the cell wall begins to become somewhat indistinct at about this stage, (Fig. 12), but in others the wall remains well defined until the tetrads are fully formed inside the original cell. In most cases the sporocytes have not separated from each other nor from the tapetal layer, and have in consequence, not yet rounded up. The loops of the thread are formed in just such a way as loops would be formed in a heavy string if two ends of the string were held between the fingers and then twisted; twisting both ends in opposite directions. Some of these loops showed more than one twist. As the loops become tighter the spirem often appears as though it contained prominent knots. The granules are still very evident on the spirem where much looping has taken place but at this stage no doubling was visible. This does not necessarily indicate that division has not taken place; the granules may be lying too close together to be separated with the magnification used, or the differentiation possble with the sarfanin-haemotoxylin stain. As the looping procceds the granules become less and less prominent until on the fully formed loops no granules are to be seen (Figs. 15, 16, 17). The loops finally break apart to form the bivalent chromosomes (Fig. 17). While chromosome formation is going on the nuclear cavity is apparently still enlarging (Figs. 15–19), but later as the nuclear wall disappears, the cytoplasm encroaches rapidly and fills the area around the contracting group of chromosomes (Figs. 20–24). Just about this time the sporocytes begin to separate from each other and assume a more rounded shape and the nuclear wall becomes more delicate. When all the loops are formed they lie around the periphery of the nucleus and can readily be seen and counted by focusing up and down. In each case the drawings were made from cells whose complete nucleus showed and had been undisturbed in the cutting. It was somewhat difficult to draw correctly those loops which were to the side of the nucleus where it was often impossible to see the actual shape. In some cases the ends

where the break occurs become fastened together, making somewhat irregularly shaped rings, some of these rings having little loops in them (Figs. 18b, 19).

In other cases, after the break occurred, the ends of the loops did not fuse, but projected as free limbs (Fig. 19). There was a great deal of difference in the newly formed chromosomes. In the figures, all the chromosomes are shown in one plane as projections, but under the microscope they were more easily distinguished and the details could be more easily traced out by focusing. The large chromosomes in the middle of Figure 18 which overlap are figured separately to show their actual form; 18a being the one on top and 18b the one below (Figs. 18a, 18b). Figures 17, 19, 18, 20, and 21, show the chromosome differences plainly; six are quite large, six small and two of intermediate size. The difference in shape is well shown in Figures 19 and 20. In the earlier stages it can easily be seen that some of the chromosomes have not doubled up nor formed complete rings. Gradually all of them twist up tighter until most of the chromosomes appear as small irregular masses (Figs. 21, 22). The nuclear wall has practically disappeared by the time the chromosomes have fully contracted (Figs. 21, 22, 23). By this time, also, the sporocyte has rounded up and withdrawn from the neighboring cells. The cytoplasm appears spongy and, in most cases, is withdrawn from the cell wall. The nucleolus seems to disappear at about the time the nuclear membrane becomes indistinct. What becomes of it was not determined but in some cases nucleolus-like masses were seen in the cytoplasm. As will appear from the above description and consideration of the figures presented, it becomes evident that the details of chromosome formation in Fuchsia does not agree with that of Oenothera as described by Gates, Davis and Geertz. The loops are formed from a very slender spirem and no thickening into a chain of univalent chromosomes is apparent. The incipient loops before the separation occurs are quite distinct and these loops were followed through their development and gradual transformation until the fully formed bivalent chromosomes were present. Although the behavior of the spirem is somewhat different from that reported for Oenothera the final result is identical. The spirem breaks up apparently into chromosome pairs which, coming to lie side by side, by folding and twisting together are transformed into bivalents in the same manner as described by Gates. The bivalents are formed by an end to end fusion and subsequent folding of pairs of univalents. The number of chromosomes could be counted in ten or twelve preparations and each count was fourteen. Figures 22 and 23 show the fully formed chromosomes before the formation of the spindle. In Figure 22 one of the large chromosomes lies out separate from the rest and all except this large one are

somewhat connected by delicate strands of material. The separation of the large chromosome from the rest may have no special significance for later all fourteen seem to be connected. The connecting strands are not evident until after the chromosomes are fully formed but appear before the spindle. In Figure 23 the connection is very distinct and the appearance is much like what Gates has shown in some of his figures.

The nuclear wall has entirely disappeared by this time and the cells are spherical. The fully formed chromosomes are of rather indefinite shape although there is a difference in size, but there is no such characteristic shapes as found by Schaffner in Lilium tigrinum and Erythronium and by Miss Hyde in Hyacynth. However, the peculiarities of size and form noted earlier are still in evidence (Fig. 24).

While the chromosomes are scattered in the nuclear cavity the delicate strands of material that connect them seem to draw them up closer into the central part of the nuclear area.

The sections were not stained with the special object of studying the spindle but when it became evident it was a bipolar structure within the nuclear cavity and the chromosomes were apparently attached to the delicate fibers. At this stage the cytoplasm has usually penetrated into the nuclear area and surrounds the spindle but occasionally the preparations show a clear surrounding space which may be due to plasmolysis (Fig. 25).

In Lilium tigrinum Schaffner found that the chromosomes in the reduction division were fastened to the spindle near the end and that as the chromosomes were pulled toward the poles the break occurred transversely causing one of the univalent chromosomes to go to each pole. In Fuchsia the chromosomes are so small and compact that no ends can be seen sticking out from the apparently homogenous mass. Even with a magnification of 2500x the chromosomes seemed perfectly homogenous. As the chromosomes are drawn into the equatorial plate they still retain their individuality and can be counted without great difficulty. At this point they are hard to draw due to the fact that they lie under each other and can be seen best by focusing.

The main purpose of the investigation was to study the formation of the bivalent chromosomes but a series of older sections brought out another point of interest that might be mentioned. There are irregularities in the development of the tetrads which may be significant in connection with the supposed hybrid nature of our greenhouse varieties of Fuchia. In some cases normal tetrads were formed, in others as high as six to eight nuclei of various sizes were observed in one sporocyte (Figs. 33, 34). This condition has been known for some time. In 1886 Wille (23) reported that he had observed as high as eight cells developed from the pollen-mother cells of Fuchsia. The same condition was

observed in Hemerocallis by Fulmer (4). In some cases the cytoplasm between two newly formed nuclei was separated although no visible wall was formed; but in most cases the nuclei were formed and remained imbedded in the general cytoplasm (Figs. 28–34). In one case a regular tripartite arrangement of three nuclei was observed and these were surrounded by separate masses of cytoplasm (Fig. 31). In none of these cases was the original sporocyte wall disintegrated. The further development of the smaller nuclei was not studied although that might be an interesting investigation.

SUMMARY.

1. In the reduction division of Fuchsia speciosa there is apparently an end to end fusion of the univalent chromosomes, forming a continuous spirem which twists and folds up into a definite number of loops which represent the incipient bivalent chromosomes, fourteen in number.

2. The loose network of the resting nucleus at an early stage begins to show a massing of chromatin material into indefinite lumps of approximately the reduced number of chromosomes. These masses probably represent the arrangement of the chromatin into a definite mosaic, preparatory to the synaptic conjugation of the univalent into the bivalent chromosomes.

3. Gradually the lumps disappear and the material seems to go toward the formation of prominent granules that arrange themselves along a delicate thread.

4. Next follows a period during which there is an evident swelling of the nucleus. In consequence of this swelling the threads are pulled loose or withdrawn from the nuclear wall, and the chromatin material collapses in a mass. It may collapse around the nucleolus or to one side of it, or it may collapse so that the nucleolus has no connection with it. The contracted portion may lie in the center of the nucleus or in contact with the nuclear wall. This synizesis is regarded as an artifact although no definite evidence was obtained for or against this supposition.

5. After the synizesis the spirem is apparently continuous and the granules appear small and evenly distributed throughout its length. At first there is little or no looping but soon the spirem begins to show that it is laid in delicate little loops. The loops are arranged on the inside of the nuclear wall. In some sporocytes as high as eight loops could be determined at a rather early stage, still more or less connected, but by the time the fourteen loops are fully formed they are usually broken apart.

6. After breaking apart the loops thicken and tighten until masses of various sizes and shapes were formed, four being quite small and five of rather large size.

7. The fully formed chromosomes are then seen to be connected by delicate strands. About this time or a little before the nuclear wall has disappeared.

8. The chromosomes are taken on to a bipolar spindle and gradually pulled into the equatorial plane.

9. There is an irregularity in the formation of the microspores. Frequently as high as eight are formed from one sporocyte.

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EXPLANATION OF PLATES I AND II.

The plates are reduced $\frac{5}{8}$ in reproduction. All the figures were drawn with a conpensating ocular 18, and an oil immersion 1/12, which makes a magnification of about 2500.

PLATE I.

Fig. 1. Microsporocyte showing the resting chromatin network.

Fig. 2. Microsporocyte showing the chromatin material beginning to collect in little lumps.

Fig. 3. Later stage showing the further development of the chromatin masses.

Fig. 4. Microsporocyte showing well formed masses with more prominent connections.

Figs. 5, 6. Microsporocytes still showing the larger chromatin masses but having well formed linin threads on which are seen chromatin granules.

Figs. 7, 8. Microsporocytes showing the spirem with granules on it and still showing some larger masses of chromatin material.

Figs. 9, 10, 11. Microsporocytes showing the chromatin material in various stages of synizesis.

Fig. 9. The microsporocyte in contraction showing a few strands on which granules may be distinctly seen.

Fig. 12. Sporocyte with the spirem well formed, showing a slight disposition to loop.

Fig. 13. Sporocyte showing well formed loops.

Fig. 14. Sporocyte showing the loops well formed.

Fig. 14a. Part of the looped spirem from Fig. 14, showing the small granules on the spirem and in one case there are two loops fastened together.

Fig. 15. Sporocyte showing that the loops have become tightened.

Fig. 16. Sporocyte showing loose and tight loops.

Fig. 17. Sporocyte in which the loops have separated from each other and show characteristic sizes and shapes.

PLATE II.

Fig. 18. Later stage of Fig. 17 in which some of the loops have become tighter.

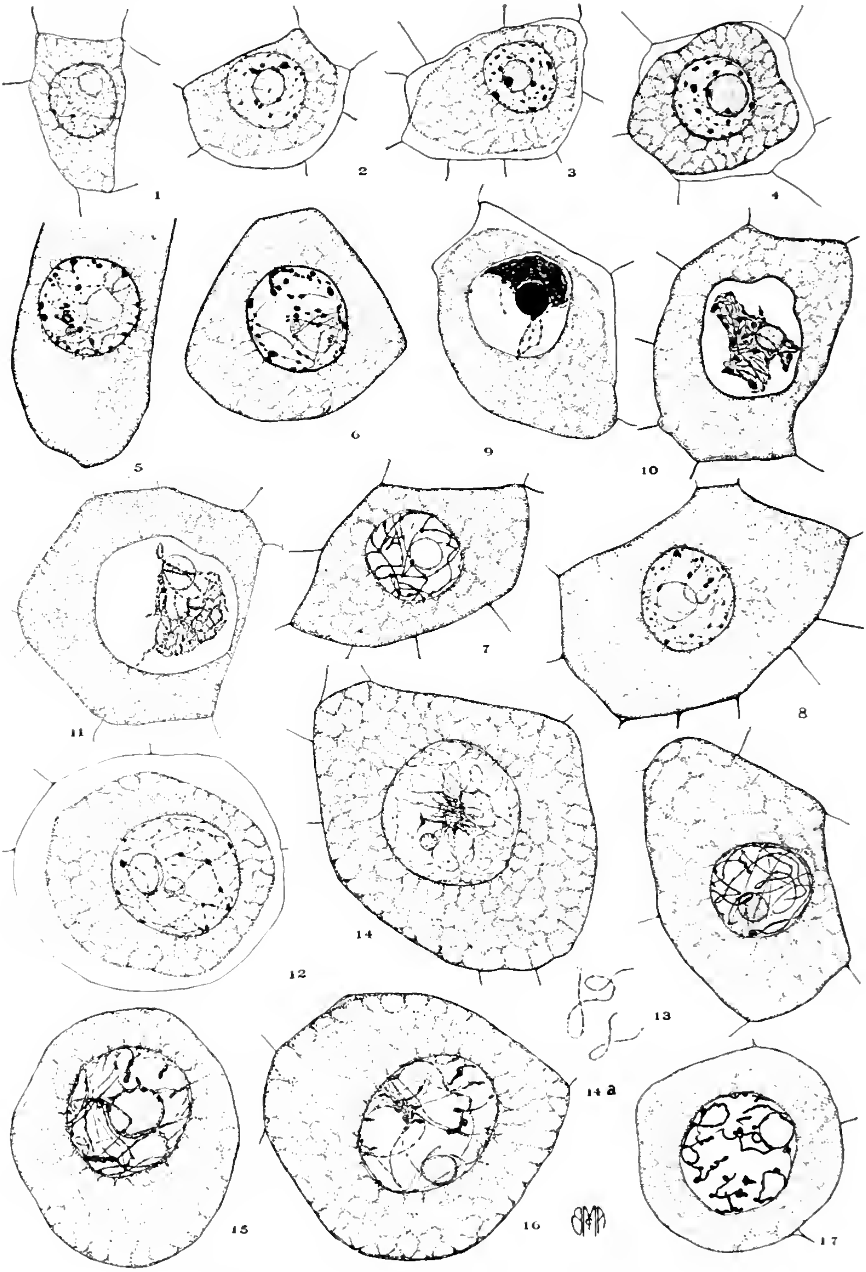
Fig. 18a. A loop from the top of the nucleus shown in Fig. 18.

Fig. 18b. A loop from the bottom of the nucleus in Fig. 18.

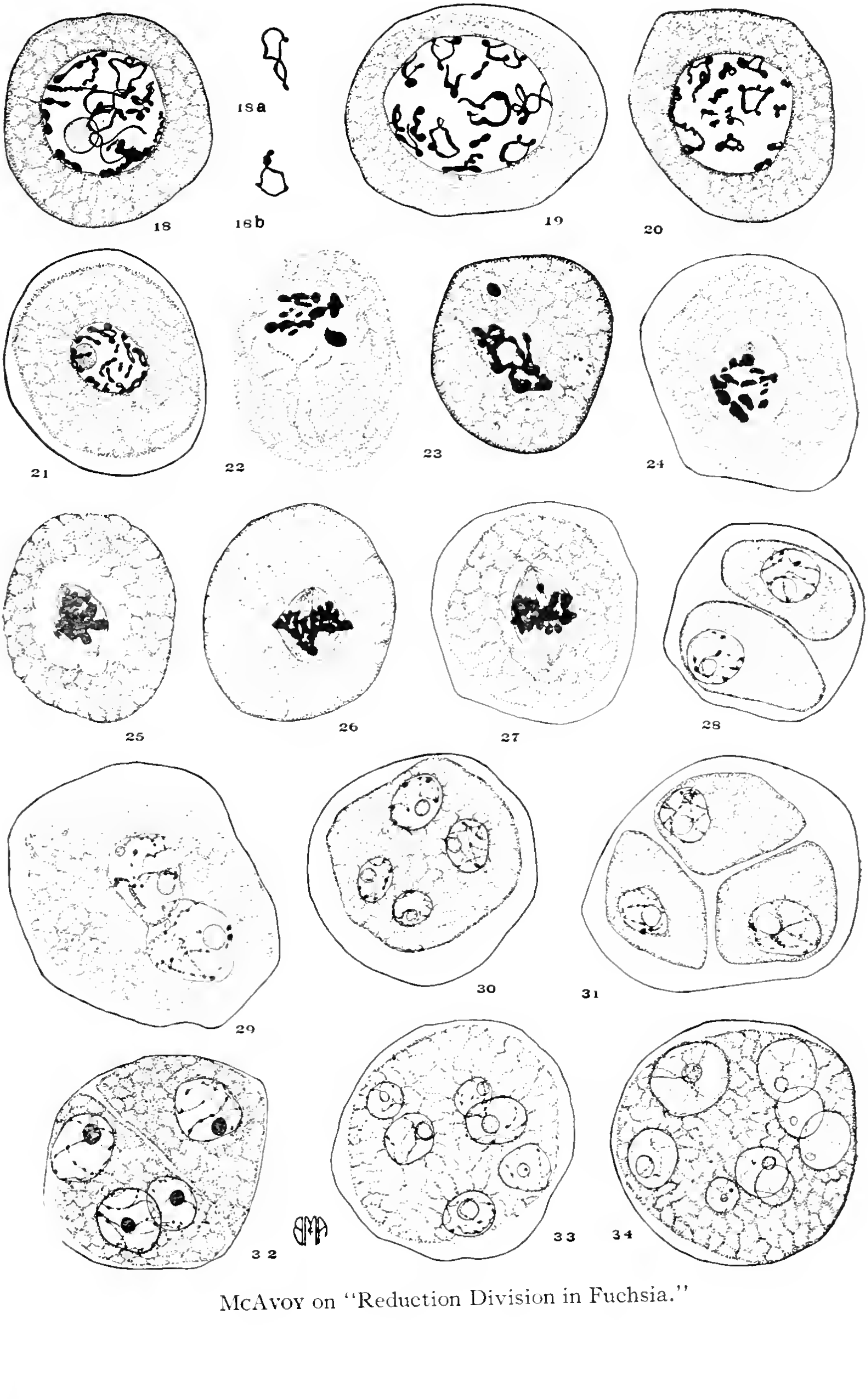
Fig. 19. Chromosome loops of various characteristic sizes and shapes. The nucleolus has disappeared.

Fig. 20. Later stage in the formation of the chromosomes. The loops are tightening.

Fig. 21. The loops have become tighter and have come to lie closer together.



McAvoy on "Reduction Division in Fuchsia."



McAvoy on "Reduction Division in Fuchsia."

Fig. 22. The chromosomes are shown lying in the nuclear area. Delicate connecting fibers are seen connecting the chromosomes.

Fig. 23. Chromosomes are seen connected by delicate strands and the cytoplasm has penetrated into the nuclear area.

Fig. 24. Chromosomes on the bipolar spindle.

Figs. 25, 26. Chromosomes on the spindle.

Fig. 27. Chromosomes near the equatorial plate.

Fig. 28. Two nuclei surrounded by cytoplasm inside the original sporocyte wall.

Fig. 29. Two nuclei imbedded in the cytoplasm of the original sporocyte.

Figs. 30, 32. Four nuclei in the cytoplasm of the original sporocyte.

Fig. 31. Three nuclei in three masses of cytoplasm inside the original sporocyte wall.

Fig. 33. Sporocyte wall and cytoplasm in which six nuclei are imbedded.

Fig. 34. Eight nuclei following the process of reduction. The cytoplasm has not begun to separate.

AN UNDESCRIBED EQUISETUM FROM KANSAS.*

John H. Schaffner.

For many years the writer has known a peculiar type of Equisetum with annual, aerial stems, growing on clayey banks and bluffs in central Kansas. This plant was referred to Braun's Equisetum laevigatum, although some of its most evident characters did not agree with the description of that species.

In 1903 (Fern Bull. **11:** 40), Eaton stated that according to his observations, E. laevigatum A. Br. was annual and this view is continued in Gray's Manual, 7th Ed. 1908, where the statement is made that the stems are "mostly annual." In a note in the Ohio Naturalist, **4:** 74, the writer agreed with Eaton and also suggested that E. laevigatum as at present understood might be a composite species. Eaton described E. hyemale intermedium and stated that it was "often confused with E. laevigatum."

The writer has had the various forms of Equisetum, which are involved in the confusion, under consideration since 1903 and has come to some definite conclusions which are here presented:

1. The annual form of Equisetum from the west usually going under the name E. laevigatum A. Br. is an undescribed species.
2. Braun's description of E. laevigatum is essentially correct.
3. Eaton's E. hyemale var. intermedium is Braun's E. laevigatum.

The writer examined the original material at St. Louis from which Engelmann sent specimens to Braun, and found that the plants agree well with Braun's description. They are perennial and the cones have a definite point. They are considerably smoother than the usual forms of E. hyemale but much rougher than the disputed plants from Kansas.

One of Engelmann's specimens of E. laevigatum A. Br. distinguished as variety B, scabrellum, collected in August, 1843, on the banks of the Mississippi below Jefferson Banks is marked in pencil as "Probably type specimen." Both branched and unbranched specimens are in the collection. This specimen has no cones. Another specimen labeled E. laevigatum A. Br. from sterile hills near harbors nine miles west of St. Louis, July, 1844, has the cone with a rigid point and agrees with the specimens the writer identified as E. laevigatum, the past summer in a trip to Kansas. It has the long dilated sheath and other distinguishing characters.

---

*Contribution from the botanical laboratory of Ohio State University, No. 70.

Several years ago, while visiting the New York Bot. Garden, the late Dr. Underwood showed the writer specimens of E. laevigatum A. Br. from Engelmann's collections made at St. Louis in August, 1843. These plants also had the rigid points on the cones. They are probably from the same material from which Braun received his specimens.

Specimens of E. hyemale intermedium in the National Herbarium at Washington and at the Missouri Bot. Garden, including cotypes named by Eaton himself, agree closely with Englemann's specimens of E. laevigatum. Some of the specimens renamed by Eaton were originally labeled E. laevigatum. One of Eaton's cotypes of E. hyemale intermedium at the Mo. Bot. Garden appears to the writer to be the same in all essential respects as Engelmann's laevigatum material. The specimens was originally labeled E. laevigatum.

There can be no mistake as to the meaning of Braun's original description of E. laevigatum as translated by Engelmann and printed in The American Journal of Science and Arts†.

The species is characterized as follows:

"Equiseta stichopora (winter-Equiseta). Stomata disposed in two distinct ranges on each side of the groove; each range formed by one or more rows of stomata (All known species in this division have hardy evergreen stems).

Homophyadica.

Ranges of stomata consisting each of one row.

7. **E. laevigatum** A. Braun.

"Stems tall, erect, simple or somewhat branching; carinae convex, obtuse, smooth; grooves shallow on each side; with a single series of stomata, vallecular air cavities small, the carinal ones very minute; central cavity large; sheaths elongated, adpressed, with a black limb, consisting of about twenty-two leaves with one carina at base and (by the elevation of the margin and depressions of the middle) two towards the point; points linear—subulate, sphacelate, caducous, leaving a truncate-dentate margin to the sheath; branches somewhat rough; sheaths with about eight indistinctly 3-carinate leaves; points persistent subulate, sphacelate with a narrow membranous margin.

Hab. On poor clayey soil with Andropogon and other coarse grasses at the foot of the rocky Mississippi hills, on the banks of the river below St. Louis.

---

†Braun, Alexander. A monography of the North American species of the genus Equisetum; translated from the author's manuscript, and with some additions, by George Engelmann. Am. Jour. Sci. and Arts **46**:81–91. (April, 1844.)

In size and manner of growth this new species is closely allied to E. hyemale, and the larger variety of E. robustum, but it is easily distinguished by its smoothness, its long green sheaths, with a narrow black limb, and its darker green color."

This description seems to be quite accurate except is some minor points. The color is usually not darker green than in E. hyemale and the sheaths are usually though not always dilated above. The color of the large Equisetums varies considerably with the environment, and in some cases the young sheaths are more or less dilated than the old ones.

The new species may be characterized as follows:

Equisetum kansanum n. sp.

Kansas Horsetail.

Aerial stems usually 1–2½ feet high, annual, very smooth, 15–30 grooved, usually without simple branches unless broken off; color mostly light-green; surface of the ridges and grooves with cross or diagonal bands; sheaths long, dilated above and usually constricted at the base, green with a narrow black band at the top; teeth deciduous; cones ovate or oblong-ovate, without a point, the apex obtuse or merely acute. On upland clayey banks along ravines and hillsides, growing in rather scattered tufts. Name derived from Kansas where the species is common.

Type locality, Bloom township, Clay County, Kansas. Specimens also from Mancos, Colorado. Type and cotype 1 deposited in the herbarium of the Ohio State University, Columbus, Ohio.

Equisetum laevigatum and Equisetum kansanum form the transition types between the large, evergreen scouring-rushes like E. hyemale and E. robustum on the one hand and the tall annual horsetails, like E. fluviatile on the other. E. laevigatum is perennial in Kansas although it often freezes down to near the surface of the ground in severe winters.

The habit of growth between the three species which are often confused is quite characteristic. E. hyemale grows in dense masses usually on creek and river banks and low places. E. laevigatum is rather tall and is more open and separate in its growth, abounding in Kansas, in sandy river bottoms where the soil is well filled with clay or other fine material and at the base of clayey bluffs. E. kansanum as stated above is also open and scattered in growth and is found mainly on clay banks along ravines and hillsides. They may be readily separated by the following key:

1. Aerial stems evergreen, rough to a greater or less degree; cones tipped with a rigid point.
   a. Sheaths cylindrical, not dilated upward, usually with 2 black bands, sometimes entirely black; stems rough, tuberculate.

      E. hyemale.
      E. robustum.

   b. Sheath elongated, dilated upward, with a narrow black band at the top and frequently with a second irregular one below; stems smoothish, only slightly tuberculate.

      E. laevigatum.

2. Aerial stems annual, smooth; cones without a point.
   a. Stems usually unbranched except when broken; sheaths elongated, dilated upward, with a narrow black band at the top, rarely with a faint second one below.

      E. kansanum.

In conclusion, the writer wishes to express his thanks to the directors and curators of the three herbaria visited, for courtesies shown in the study of the valuable materials without which the solution of the problem to the writer's satisfaction would have been much more difficult.

CONCERNING OHIO POLYPORACEÆ.

L. O. Overholts.

In the June number of the Ohio Naturalist for 1911 an article by the present writer appeared entitled "The Known Polyporaceæ of Ohio." Since the appearance of that article attention has been called to certain omissions, both in the enumeration of the species and in the bibliolgraphy that was appended, and it was thought best to take this means of making the corrections.

The paper was a preliminary list of species intended to be used as the basis for a key to the genera and species. Illustrations were cited and a bibliography was appended in the effort to get collectors in different localities to give some attention to this group, in order that some definite knowledge of the number and identity of the species might be obtained. The list was based on the writings of Berkeley, Hard, Lea, Lloyd, Montagne, Morgan and Murrill.

Several collections of specimens were recieved from correspondents in various parts of the state and specimens were examined in the state herbarium at Columbus and in the Lloyd museum at Cincinnati. Many collections were made in the Miami valley by persons connected with the department of Botany at Miami University. These latter are for the most part in the writer's

herbarium at present. During the fall of 1911 the writer spent several days in collecting in hitherto unvisited localities. In August of the present year four weeks were spent at the New York Botanical Gardens where are found a number of collections from Ohio. In these ways it has been possible to gain some knowledge of the Ohio Polyporaceæ. The work is by no means completed. But the results are judged to be of sufficient value to warrant the publication, in the near future, of a key to the genera and species.

In the former paper 118 species were listed. This included 31 species, mostly of the genus Poria, that have been dropped from the list. The literature and the herbarium material of this genus are so confused that it is impracticable to spend time on them. At the present time the list includes 87 species that are known to have been collected in Ohio and of which good specimens may be found. Besides these, there are 10 other species, never collected in the state as far as known, but the geographical distribution of which is such as to make it extremely probable that more sysmatic collecting will bring them to light. Another species is of such doubtful standing as to exclude it from the list.

It was not within the limits of the former paper to include in the bibliography any except the best and most accessible writings on the family. The citations in the supplementary list given below are to important writings that were examined in making out the list of species, but which were unintentionally overlooked in preparing the bibliography.

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Missouri Botanical Garden.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, October, 7 1912.

The meeting was called to order by President Barrows. The secretary being absent Professor Schaffner was appointed secretary pro tem. No minutes of the previous meeting being at hand, this order was omitted.

The papers of the evening consisted of reports of the past summer's work and observations.

Prof. F. L. Landacre gave a report of neurological work done at the University of Chicago. The type studied was Rana vipiens.

Prof. J. H. Schaffner gave some observations on various forms of Amaranthus retroflexus. A number of striking leaf-patterns were found in Ohio and Kansas. Seeds were collected and will be planted in order to determine the status of these forms. He also spoke of the nature and distribution of trees in the prairie regions of Kansas.

Prof. C. H. Goetz spent some time in Northeastern Nebraska and in Florida. In Nebraska the bluffs and hills facing the northeast are wooded while those facing the opposite direction are without trees. In Florida, forest conditions are not very favorable. Eucalyptus trees do not grow well and the soil seems unsuitable in many places for vigorous tree growth.

Prof. A. Dachnowski studied the question of absorption and wilting point of plants and also the relation of root systems to each other and to the substratum in order to determine the amount of antagonism or correlation present. The latter observations were made on plants at Buckeye Lake. He regarded the mutual relation as being a physical rather than a chemical or biological one.

Prof. W. M. Barrows reported on making an accurate map of Cedat Point. The topographic maps were found to be incorrect in some particulars.

After the president was given authority to appoint a committee to nominate officers, the society adjourned.

John H. Schaffner, *Secretary pro tem.*

Date of Publication, Nov. 8, 1912.

DECEMBER,

VOLUME XIII. 1912. NUMBER 2.

THE OHIO NATURALIST

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TABLE OF CONTENTS.

A LIST OF FUNGI OF CEDAR POINT.

CHAS. K. BRAIN.

The following list of 219 species of fungi for Cedar Point and vicinity, contain, I believe, 138 new records for that district. The remaining 81 species are accounted for as follows:

22 species of Myxomycetes listed in "The Ohio Naturalist" February, 1912.*

46 species of fungi in the Lake Laboratory Herbarium.

13 further species collected by the late Dr. Kellerman, at Sandusky, 1903.

Where these are mentioned in the list and merely indicated by "Ohio Nat.," "L. L. Herb.," or "Sandusky, W. A. K.," it is intended to imply that they were not seen this year. In all other cases specimens were collected between June 15, and August 15 Very few species are given for places around Cedar Point, but occasional excursions were made, for the day, to places of interest, such as Castalia, Put-in-Bay, Kelly's Island and Huron. Material collected on these trips was included, on the suggestion of Dr. L. H. Pammel, of Ames, Iowa, to whom I wish to express my sincere appreciation for unfailing kindness in bringing in material and for checking determinations. My thanks are also due to Prof. E. L. Fullmer, of Berea, Ohio, for permission to include the Myxomycetes which he determined, and to Prof. R. F. Griggs, of Ohio State University, for advice and criticism.

The species marked "det. C. H. P." were very kindly determined for me by Dr. C. H. Peck, Botanist of New York State.

*Fullmer, "A Preliminary List of the Myxomycetes of Cedar Point." OHIO NAT. 12:

MYXOMYCETES.

Physaraceæ.

1. **Fuligo violacea** Pers. Coll. C. K. B. Cedar Pt.
2. **Tilmadoche alba** (Bull.) Macbr. Ohio Nat.
3. **Badhamia orbiculata**. Rex. Ohio Nat.
4. **Physarella oblonga** (Berk. and Cke.) Morgan. Ohio Nat.
5. **Craterium minimum** B. & C. Coll. Prof. E. L. Fullmer. Cedar Pt.
6. **Mucilago spongiosa** (Leyss.) Morgan. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.
7. **Didymium crustaceum**. Fries. Ohio Nat.
8. **Didymium squamulosum** (Alb. & Schw.) Fries. Ohio Nat.
9. **Didymium melanospermum** (Pers.) Macbr. Coll. C. K. B. Cedar Pt.
10. **Diderma reticulatum** (Rost.) Morgan. Coll. Prof. E. L. Fullmer. Cedar Pt.
11. **Diderma crustaceum** Peck. Ohio Nat. Coll. C. K. B. Cedar Pt.

Stemonitaceæ.

12. **Stemonitis maxima** Schw. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.
13. **Stemonitis fenestrata** Rex. Ohio Nat. Coll. C. K. B. Cedar Pt.
14. **Stemonitis smithii** Macbr. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.
15. **Comatricha stemonitis** (Scop.) Sheldon. Coll. Prof. E. L. Fullmer. Cedar Pt.
16. **Diachea leucopoda** (Bull.) Rost. Coll. Prof E. L. Fullmer. Cedar Pt.

Cribrariaceæ.

17. **Lindbladia effusa** (Ehr.) Rost. Ohio Nat.
18. **Tubifera ferruginosa** (Batsch.) Macbr. Ohio Nat.
19. **Dictydium cancellatum** (Batsch.) Macbr. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.

Lycogalaceæ.

20. **Lycogola epidendrum** (Buxb.) Fries. Ohio Nat. Coll. C. K. B. Cedar Pt.
21. **Lycogala flavo-fuscum** (Ehr.) Rost. Ohio Nat.

Trichiaceæ.

22. **Ophiotheca wrightii** Berk. and Curtis. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.
23. **Perichæna quadrata** Macbr. Coll. Prof. E. L. Fullmer. Cedar Pt.
24. **Lachnobolus globosus** (Schw.) Rost. Ohio Nat.

25. **Arcyria nutans** (Bull.) Grev. Ohio Nat. Coll. C. K. B. Cedar Pt.
26. **Arcyria incarnata** Persoon. Coll. Prof. E. L. Fullmer. Cedar Pt.
27. **Arcyria denudata** (Linn.) Sheldon. Ohio Nat. Coll. Prof. E. L. Fullmer. Cedar Pt.
28. **Arcyria cinerea** (Bull.) Pers. Ohio Nat. Coll. C. K. B. Cedar Pt.
29. **Hemitrichia vesparium** (Batsch.) Macbr. Coll. Prof. E. L. Fullmer, Cedar Pt.
30. **Hemitrichia stipitata** Mass. Coll. Prof. E. L. Fullmer. Cedar Pt.
31. **Hemitrichia intorta** Lister. Ohio Nat.
32. **Hemitrichia clavata** (Pers.) Rost. Coll. C. K. B. Cedar Pt.
33. **Trichia inconspicua** Rost. Ohio Nat.

PHYCOMYCETES.

CHYTRIDIALES.

34. **Synchytrium decipiens** Farl. On Amphicarpa monoica (L.) Ell. Coll. C. K. B. Cedar Pt.

PERONOSPORALES.

35. **Cystopus bliti** (Biv.) Lév. On Amaranthus retroflexus L. Coll. Dr. L. H. Pammel. Cedar Pt. and Kelly's Is. Coll. C. K. B. Gypsum.
36. **Cystopus candidus** (Pers.) Lév. On Capsella bursa-pastoris (L.) Medic., Lepidium campestre (L.) R. Br., Lepidium virginicum L. Radicula hispida (Desv.) Rob., Sisymbrium canescens Nutt. Coll. C. K. B. Cedar Pt. On Sisymbrium officinale (L.) Scop. Coll. Dr. L. H. Pammel. Kelly's Is.
37. **Plasmopara sordida** Berk. On Scrophularia marylandica L. Coll. Sandusky. W. A. K.
38. **Plasmopara viticola** (B. & C.) Berl. and De Toni. On Vitis vulpina L. Coll. C. K. B. Cedar Pt. Coll. Dr. L. H. Pammel on Vitis bicolor Lec. Huron.
39. **Peronospora australis** Speg. On Sicyos angulatus L. Coll. C. K. B. Castalia.
40. **Peronospora geranii** Pk. On Geranium maculatum L. Coll. C. K. B. Cedar Pt.
41. **Peronospora parasitica** (P.) Tul. On Lepidium virginicum L. Coll. Dr. L. H. Pammel. Cedar Pt.

MUCORALES.

42. **Mucor stolonifer** Ehr. On Bread. Coll. C. K. B. Cedar Pt.

ENTOMOPHTHORALES.

43. **Empusa grylli** (Fres.) Nowakowski. On Trimerotropis maritima Harris. Melanoplus differentialis Uhler. Melanoplus bivittatus Say. Coll. C. K. B. Cedar Pt.

ASCOMYCETES.

PEZIZALES.

44. **Lachnea scutellata** L. On log. Coll. C. K. B. Put-in-Bay. Coll. Dr. L. H. Pammel. Cedar Pt.
45. **Macropodia semitosta.** On logs. Coll. C. K. B. Cedar Pt.
46. **Sclerotinia fructigena** (Pers.) Schroet. On Prunus avium L. Coll. Dr. L. H. Pammel. Huron.
47. **Pseudopeziza medicaginis** (Lib.) Sacc. On Medicago sativa L. Coll. C. K. B. Put-in-Bay; Cedar Pt.

ASPERGILLALES.

48. **Aspergillus herbariorum** Wiggers. On botanical specimens. Coll. C. K. B. Cedar Pt.
49. **Aspergillus niger** van Tiegh. On Bread. Coll. C. K. B. Cedar Pt.
50. **Penicillium crustaceum** Linn. On Bread, etc. Coll. C.K.B. Cedar Pt.

PERISPORIALES.

51. **Sphærotheca castagnei** Lév. On Taraxacum officinale Weber. Coll. C. K. B. Cedar Pt. On Bidens sp. Coll. Dr. L. H. Pammel. Sandusky.
52. **Podosphæra oxyacanthæ** (DC.) De Bary. On Prunus virginiana L. Coll. C. K. B. Cedar Pt.
53. **Erysiphe cichoracearum** DC. On Lappula virginiana (L.) Greene. Parietaria pennsylvanica Muhl. Phlox divaricata L. Solidago candensis L. Verbena hastata L. Coll. C. K. B. Cedar Pt.

    On Vernonia maxima Small. Coll. Dr. L. H. Pammel. Huron.
54. **Erysiphe communis** (Wallr.) Fr. On Geranium maculatum L. Coll. Dr. L. H. Pammel. Cedar Pt.
55. **Erysiphe montagnei** Lév. On Taraxacum officinale Weber. Coll. C. K. B. Cedar Pt.
56. **Erysiphe polygoni** DC. On Oenothera biennis L. Coll. C. K. B. Cedar Pt.
57. **Microsphæra alni** (DC.) Wint. On Evonymus atropurpureus Jacq. Apios tuberosa Mœnch. Coll. C. K. B. Cedar Pt.
58. **Microsphæra diffusa** C. & P. On Desmodium canescens (L.) DC. Coll. C. K. B. Black Channel, Cedar Pt.
59. **Microsphæra ravenellii** Berk. On Lathyrus palustris L. Coll. C. K. B. Black Channel, Cedar Pt.
60. **Phyllactinia corylea** (Pers.) Karst. On Celastrus scandens L. Coll. C. K. B. Cedar Pt.

HYPOCREALES.

61. **Cordyceps militaris** (Linn.) Link. On larva (in eoeoon) of Isia isabella. Coll. A. R. Shadle. Cedar Pt.
62. **Claviceps purpurea** (Fr.) Tul. On Ammophila arenaria (L.) Link. Coll. C. K. B. Cedar Pt.

DOTHIDEALES.

63. **Plowrightia morbosa** (Sehw.) Saee. On Prunus virginiana Linn. Coll. C. K. B. Cedar Pt.

SPHÆRIALES.

64. **Guignardia bidwellii** (Ell.) Viala. and Ravaz. (Phyllostieta.) On Vitis vulpina L.. Coll. C. K. B. Cedar Pt.
65. **Diaporthe ailanthi** Saee. On Ailanthus glandulosa Desf. Coll. C. K. B. Cedar Pt.
66. **Hypoxylon** sp. On log. Coll. C. K. B. Cedar Pt.
67. **Daldinia cingulata** (Lev.) Sacc. On log. Coll. C. K. B. Cedar Pt.
68. **Xylaria digitata** (Linn.) Grev. On Log. Coll. C. K. B. Cedar Pt.
69. **Xylaria polymorpha** (Pers.) Grev. On log. Coll. C. K. B. Cedar Pt.

BASIDIOMYCETES.

USTILAGINALES.

70. **Ustilago avenæ** (Pers.) Jens. On Avena sativa L. Coll. C. K. B. Cedar Pt.
71. **Ustilago hordei** (P.) Kell. and Swingle. On Hordeum vulgare L. Coll. Dr. L. H. Pammel. Sandusky.
72. **Ustilago zeæ** (Beekm.) Ung. On Zea mays L. Coll. Dr. L. H. Pammel. Sandusky.

TILLETIALES.

73. **Entyloma menispermi** Farl et Trel. On Menispermum eanadense L. Sandusky, W. A. K.

UREDINALES.

Melampsoraceæ.

74. **Coleosporium sonchi-arvensis** (P.) Lev. On Solidago serotina Ait. Coll. C. K. B. Cedar Pt.
75. **Melampsora salicis-capreæ** (P.) Wint. On Salix alba L. Coll. C. K. B. Cedar Pt.
76. **Pucciniastrum agrimoniæ** (DC.) Diet. On Agrimonia gryposepala Wallr. Coll. C. K. B. Cedar Pt.
    On A. mollis. Sandusky. W. A. K.

Pucciniaceæ.

77. **Gymnosporangium globosum** Farl. On Juniperus virginiana L. Coll. Prof. E. L. Fullmer. Cedar Pt.
78. **Gymnosporangium nidus-avis** Thaxter. On Juniperus virginiana L. Coll. C K. B. Cedar Pt.

79. **Puccinia caricis** (P.) Fckl. On Carex laxiflora Lam. Coll. C. K. B. Cedar Pt.
80. **Puccinia coronata** Cda. On Avena sativa L. Coll. Dr. L. H. Pammel. Sandusky.
81. **Puccinia fraxinata** (Lk.) Arthur. (Teleuto). On Spartina dactyloides (L.) Willd. Sandusky. W. A. K.
82. **Puccinia glechomatis** DC. On Agastache nepetoides (L.) Ktze. Coll. C. K. B. Cedar Pt.
83. **Puccinia graminis** Pers. On Avena sativa L. Coll. Dr. L. H. Pammel. Sandusky.
84. **Puccinia helianthi** Schw. On Helianthus hirsutus Raf. Sandusky. W. A. K.
85. **Puccinia malvacearum** Mont. On Hollyhock, Althæa sp. Coll. Dr. L. H. Pammel. Sandusky.
86. **Puccinia menthæ** Pers. On Mentha canadensis L. and Satureja vulgaris (L.) Fritsch. Coll. C. K. B. Cedar Pt.
87. **Puccinia osmorhizæ** C. & P. On Osmorhiza claytoni (Michx.) Clarke. Coll. C. K. B. Cedar Pt.
88. **Puccinia podophylli** S. On Podophyllum peltatum L. Coll. C. K. B. Cedar Pt. and Castalia.
89. **Puccinia polygoni-amphibii** Pers. On Polygonum virginianum L. Sandusky. W. A. K.
90. **Puccinia seymeriæ** Burrill. On Afzelia macrophylla (Nutt.) Kuntze. Sandusky. W. A. K.
91. **Puccinia simplex** Peck. On Hordeum vulgare L. Coll. Dr. L. H. Pammel. Sandusky.
92. **Puccinia taraxaci** Plw. On Taraxacum officinale Weber. Coll. C. K. B. Cedar Pt.
93. **Puccinia xanthii** Schw. On Xanthium commune Britton. Coll. C. K. B. Cedar Pt. Put-in-Bay, and Huron.
94. **Gymnoconia peckiana** Howe. (Caeoma). On Rubus allegheniensis Porter, and Rubus idaeus L. Coll. C. K. B. Cedar Pt.
95. **Phragmidium obtusum** Wint. On Potentilla canadensis L. Coll. Dr. L. H. Pammel. Sandusky.
96. **Uromyces euphorbiæ** C. & P. On Euphorbia preslii Guss. Coll. C. K. B. Cedar Pt.
    On E. maculata L. Coll. Dr. Pammel. Sandusky.
97. **Uromyces phaseoli** (Pers.) Wint. On Strophostyles helvola (L.) Britt. Sandusky. W. A. K.
98. **Uromyces striatus** Schroet. On Medicago lupulina L. Coll. Dr. L. H. Pammel. Sandusky.
99. **Uromyces toxicodendri** Berk. and Rav. On Rhus toxicodendron L. Coll. Cedar Pt. W. A. K. Sep. 22, 1902.
100. **Uromyces trifolii** (Hedw.) Lev. On Trifolium hybridum L. and Trifolium pratense L. Coll. Dr. L. H. Pammel. Huron.

Aecidium-forms.

101. **Aecidium (Gymnosporangium) nidus-avis** Thaxter. On Amelanchier canadensis (L.) Medic. Coll. C. K. B. Cedar Pt.
102. **Aecidium cimicifugatum** S. On Cimicifuga racemosa Nutt. Coll. C. K. B. Cedar Pt.
103. **Aecidium compositatum** Mart. On Aster sp. Coll. Dr. Pammel. Huron. On Erigeron pulchellus Michx. Coll. C. K. B. Cedar Pt. On Eupatorium perfoliatum L. Lactuca canadensis L. and Silphium terebinthinaceum Jacq. Coll. Dr. L. H. Pammel. Castalia.
104. **Aecidium fraxini** S. On Fraxinus americana L. and Fraxinus viridis Michx. Coll. C. K. B. Cedar Pt.
105. **Aecidium grossulariæ** DC. On Ribes cynosbati L. and Ribes floridum L'Hérit. Coll. Dr. L. H. Pammel. Cedar Pt.
106. **Aecidium impatientis** S. On Impatiens biflora Walt. Coll. C. K. B. Cedar Pt. Huron and Gypsum.
107. **Aecidium nesææ** Gerard. On Decodon verticellatus (L.) Ell. Coll. Prof. E. L. Fullmer. Cedar Pt.
108. **Aecidium oenotheræ** Pk. On Oenothera biennis L. Coll. C. K. B. Cedar Pt. and Gypsum.
109. **Aecidium pammelii** Trelease. On Euphorbia corollata L. Coll. C. K. B. Cedar Pt.
110. **Aecidium pustulatum** M. A. Curtis. On Comandra umbellata (L.) Nutt. Coll. C. K. B. Cedar Pt.

TREMELLALES.

111. **Tremella candida** L. L. Herb. Coll. C. K. B. Cedar Pt.

DACRYOMYCETALES.

112. **Calocera cornea** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.

HYMENOMYCETALES.

113. **Stereum candidum** Schw. L. L. Herb.
114. **Stereum disciforme** DC. L. L. Herb.
115. **Stereum fasciatum** Schw. det. C. H. P. Coll. C. K. B. Cedar Pt.
116. **Stereum versicolor** (Schw.) Fr. L. L. Herb. Coll. C. K. B. Cedar Pt.
117. **Clavaria flaccida** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
118. **Clavaria pyxidata** Pers. det. C. H. P. Coll. C. K. B. Cedar Pt.
119. **Irpex cinnamonea** Fr. det. C. H. P. Coll. C. K B. Cedar Pt.
120. **Irpex lacteus** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
121. **Fomes applanatus** Pers. Coll. C. K. B. Cedar Pt.
122. **Polyporus arcularius** (Batsch.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.

123. **Polyporus carneus** Nees. det. C. H. P. Coll. C. K. B. Cedar Pt.
124. **Polyporus gilvus** Schw. det. C. H. P. Coll. C. K. B. Cedar Pt.
125. **Polyporus schweinitzii** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
126. **Polyporus sulphureus** Fr. Coll. C. K. B. Cedar Pt.
127. **Polystictus cinnabarinus** (Jacq.) Fr. det. C. H P. Coll. C. K. B. Cedar Pt.
128. **Polystictus hirsutus-albiporus.** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
129. **Boletus chrysenteron** Fr. det. C. H. P. Coll. Miss E. D. Faville. Cedar Pt.
130. **Boletus piperatus** Bull. det. C. H. P. Coll. C. K. B. Cedar Pt.
131. **Strobilomyces strobilaceus** (Scop.) Berk. Coll. C. K. B. Cedar Pt.

Agaricaceæ.

(a) **Leucosporæ.**

132. **Lenzites sepiaria** (Wulf.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
133. **Schizophyllum commune** Fr. Coll. C. K. B. Cedar Pt. Also L. L. Herb. as S. alnea (L.) Schroet.
134. **Marasmius albiceps** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
135. **Marasmius candidus** Bolt. L. L. Herb.
136. **Marasmius nigripes** (Schw.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
137. **Marasmius siccus** Schw. det. C. H. P. Coll. C. K. B. Cedar Pt.
138. **Marasmius trullisatipes** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
139. **Lentinus sulcatus** Berk. L. L. Herb.
140. **Panus rudis** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
141. **Amanita phalloides** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
142. **Amanitopsis vaginata** Bull. Coll. C. K. B. Cedar Pt.
143. **Lepiota adirondackensis** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
144. **Lepiota cristata** A. and S. det. C. H. P. Coll. C. K. B. Cedar Pt.
145. **Lepiota erminea** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
146. **Lepiota illinita** Fr. det. C. H. P. Coll. C. K. B Cedar Pt.
147. **Tricholoma albo-flavidum** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
148. **Clitocybe infundibuliformis-membranacea** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.

149. **Mycena capillaris** Schum. Coll. C. K. B. Cedar Pt.
150. **Collybia dryophila** (Bull.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
151. **Collybia delicatella** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
152. **Collybia myriadophylla** Pk. L. L. Herb.
153. **Collybia platyphylla** Fr. L. L. Herb.
154. **Lactarius rimosellus** Pk. det. C. H. P. Coll. C. K. B. Cedar Pt.
155. **Lactarius subdulcis** (Bull.) Fr. det. C. H. P. Coll. Miss E. D. Faville. Cedar Pt.
156. **Lactarius theiogalus** (Bull.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
157. **Russula alutacea** Fr. det. C. H. P. Coll. Miss Marie F. McLellan. Cedar Pt.
158. **Russula compacta** Frost. det. C. H. P. Coll. C. K. B. Cedar Pt.
159. **Russula fœtens** (Pers.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
160. **Russula pectinata** (Bull.) Fr. det. C. H. P. Coll. A. R. Shadle Cedar Pt.
161 **Russula xerampelina** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.

(b) **Rhodosporæ.**

162. **Pleurotus sapidus** Kalchb. L. L. Herb.
163. **Pluteus cervinus** (Schaeff.) Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
164. **Entoloma** sp. det. C. H. P. Coll. C. K. B. Cedar Pt.

(c) **Ochrosporæ.**

165. **Inocybe** sp. det. C. H. P. Coll. C. K. B. Cedar Pt.
166. **Galera** sp. det. C. H. P. Coll. C. K. B. Cedar Pt.

(d) **Melanosporæ.**

167. **Agaricus comtulus** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.
168. **Psilocybe ammophila** Mont. L. L. Herb.
169. **Coprinus micaceus** (Bull.) Fr. Coll. C. K. B. Cedar Pt.
170. **Coprinus fuscescens** (Schaeff.) Fr. Coll. C. K. B. Cedar Pt.
171. **Gomphidius*** sp. det. C. H. P. Coll. C. K. B. Cedar Pt.

LYCOPERDALES.

Lycoperdaceæ.

172. **Lycoperdon pusillum** Pers. det. C. H. P. Coll. C. K. B. Cedar Pt.
173. **Lycoperdon pyriforme** Schaeff. det. C. H. P. Coll. C. K. B. Cedar Pt.
174. **Geaster hygrometricus** Pers. Coll. C. K. B. Cedar Pt.

*Genus hitherto unknown in Ohio according to Stover, 1912.

NIDULARIALES.

Nidulariaceæ.

175. **Cyathus striatus** (Huds.) Hoff. Coll. Prof. R. Griggs. Cedar Pt.

PLECTOBASIDIALES.

Tulostomataceæ.

176. **Tulostoma fimbriatum** Fr. det. C. H. P. Coll. C. K. B. Cedar Pt.

FUNGI IMPERFECTI.

SPHÆROPSIDALES.

177. **Phyllosticta cruenta** (Fr.) Kicks. On Polygonatum commutatum (R. & S.) Dict. and Smilacina stellata (L.) Desf. Coll. C. K. B. Cedar Pt.
178. **Phyllosticta iridis** E. & E. On Iris versicolor L. Sandusky. W. A. K.
179. **Phyllosticta palustri** Ell. and Kell. On Stachys palustris L. Coll. C. K. B. Cedar Pt.
180. **Phyllosticta phaseolina** Sacc. On Strophostyles helvola (L.) Britton. Coll. C. K. B. Cedar Pt.
181. **Phoma uvicola** B. & C. On Psedera quinquefolia Michx. and Vitis vulpina L. Coll. C. K. B. Cedar Pt.
182. **Cicinnobolus cesatii** DeBary. On Erysiphe cichoracearum DC. Coll. C. K. B. Cedar Pt.
183. **Septoria ægopodii** Desm. On Osmorhiza claytoni (Michx.) Clarke and O. longistylis DC. Coll. C. K. B. Cedar Pt.
184. **Septoria aquilegiæ** Ell. and Kell. On Aquilegia canadensis L. Coll. Miss Marie F. McLellan. Cedar Pt.
185. **Septoria erigerontis** Pk. On Erigeron pulchellus Michx. Coll. C. K. B. Cedar Pt. On E. annuus (L.) Pers. Sandusky. W. A. K.
186. **Septoria lactucicola** Ell. and Martin. On Lactuca scariola L. Coll. Dr. L. H. Pammel. Cedar Pt.
187. **Septoria littorea** Sacc. On Apocynum cannabinum L. Coll. C. K. B. Cedar Pt.
188. **Septoria lophanthi** Wint. On Agastache nepetoides (L.) Ktze. Coll. C. K. B. Cedar Pt.
189. **Septoria musiva** Pk. On Populus tremuloides Michx. Coll. C. K. B. Cedar Pt.
190. **Septoria ochroleuca** B. & C. On Castanea dentata (Marsh.) Borkh. Sandusky. W. A. K.
191. **Septoria œnotheræ** B. & C. On Oenothera biennis L. Coll. C. K. B. Cedar Pt.
192. **Septoria podophyllina** Pk. On Podophyllum peltatum L. Coll. C. K. B. Cedar Pt.

193. **Septoria polygonorum** Desm. On Polygonum lapathifolium L. Coll. C. K. B. Cedar Pt.
194. **Septoria rubi** Wests. On Rubus allegheniensis Porter. and Rubus idæus L. Coll. C. K. B. Cedar Pt.
195. **Septoria scrophulariæ** Westd. On Scrophularia marilandica L. Coll. Dr. L. H. Pammel. Cedar Pt.
196. **Septoria violæ** Westd. On Viola pubescens Ait. Coll. C. K. B. Cedar Pt.

MELANCONIALES.

197. **Gleosporium irregulare** Pk. On Fraxinus americana L. Coll. C. K. B. Cedar Pt.
198. **Gleosporium nervisequum** (Fckl.) Sacc. On Platanus occidentalis L. Coll. C. K. B. Cedar Pt.
199. **Gleosporium septorioides** Sacc. On Quercus imbricaria Michx. Miss Marie F. McLellan. Cedar Pt.
200. **Marsonia toxicodendri** (E. & M.) Sacc. On Rhus toxicodendron L. Sandusky. W. A. K.
201. **Cylindrosporium padi** Karst. On Prunus virginiana L. Coll. C. K. B. Cedar Pt.

HYPHOMYCETES.

Mucedinaceæ.

202. **Rhinotrichum curtisii** Berk. On rotten log of Platanus occidentalis L. Sandusky. W. A. K.
203. **Ovularia obliqua** Oud. On Rumex crispus L. Coll. C. K. B. Cedar Pt.
204. **Didymaria ungeri** Cda. On Anemone canadensis L. and Ranunculus pennsylvanicus L. Coll. C. K. B. Cedar Pt.
205. **Ramularia arvensis** Sacc. On Potentilla monspeliensis L. Coll. C. K. B. Cedar Pt.
206. **Ramularia celastiri** Ell. & M. On Celastrus scandens L. Coll. C. K. B. Cedar Pt.
207. **Ramularia variabilis** Fckl. On Verbascum thapsus L. Coll. C. K. B. Cedar Pt.

Dematiaceæ.

208. **Helminthosporium teres** Sacc. On Hordeum vulgare L. Coll. Dr. L. H. Pammel. Sandusky.
209. **Macrosporium saponariæ** Pk. On Saponaria officinalis L. Coll. C. K. B. Cedar Pt.
210. **Macrosporium solani** E. & M. On Potato. Coll. Dr. L. H. Pammel. Sandusky.
211. **Cercospora chenopodii** Fres. On Atriplex hastatum Gray. Coll. Dr. L. H. Pammel. Sandusky.
212. **Cercospora clavata** (Gerard). Pk. On Asclepias syriaca L.
213. **Cercospora helianthi** E. & E. On Helianthus hirsutus Raf. and Helianthus mollis Lam. Sandusky. W. A. K.

214. **Cercospora maianthemi** Fckl. On Maianthemum canadense Desf. Coll. C. K. B. Cedar Pt.
215. **Cerscopora monoica** Ell. and Holw. On Amphicarpa monoica Elliot. Coll. C. K. B. Cedar Pt.
216. **Cercospora osmorhizæ** Ell. & Ev. On Osmorhiza claytoni (Michx.) Clarke. Coll. C. K. B. Cedar Pt.
217. **Cercospora oxybaphi** Ell. & Halsted. On Oxybaphus nyctagineus Sweet. Coll. C. K. B. Cedar Pt.
218. **Cercospora tuberosa** Ell. & Kell. On Apios tuberosa Mœnch.

Tuberculariaceæ.

219. **Tubercularia persicina** Ditm. On Aecidium compositarum Mart. Coll. C. K. B. Cedar Pt.

NEW AND RARE PLANTS ADDED TO THE OHIO LIST IN 1912.*

John H. Schaffner.

Dryopteris clintoniana x **spinulosa.** Brown's Lake, Wayne Co.; L. S. Hopkins.

Dryopteris cristata x **spinulosa.** Brown's Lake and Fox Lake, Wayne Co.; L. S. Hopkins.

Dryopteris cristata x **intermedia.** Brown's Lake and Fox Lake, Wayne Co.; Burton, Geauga Co.; L. S. Hopkins.

Eleocharis mutata (L.) R. & S. Quadrangular Spike-rush. Round Lake, Ashland Co.; L. S. Hopkins.

Juncus monostichus Bartlett. Dry open hills. Phalanx, Trumbull Co.; Almon N. Rood.

Viola pedata L. Bird's-foot Violet. Ironton, Lawrence Co.; Lillian Humphrey.

Apocynum urceolifer Mill. Urn-flowered Dogbane. St. Marys, Auglaize Co.; collected by A. Wetzstein; reported by Lillian Humphrey.

Apocynum album Greene. River-bank Dogbane. Lake, Holmes, Coshocton, Mercer, Montgomery, Butler, Clermont; reported by Lillian Humphrey.

Lycopus communis Bickn. Common Bugle-weed. Barnesville, Belmont Co.; Emma E. Laughlin.

Aster prenanthoides porrectifolius Port. Huntington, Lorain Co.; collected by A. E. Ricksecker; reported by F. O. Grover (Oberlin College Herb.).

Lacinaria scariosa (L.) Hill. Large. Blazing-star. Sugar Grove, Fairfield Co., R. F. Griggs.

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*Presented at the annual meeting of the Ohio Acad. of Sci., Columbus, Nov. 29, 1912.

THE ORDOVICIAN SECTION IN THE MANITOULIN AREA OF LAKE HURON.

AUG. F. FOERSTE.

1. INTRODUCTION.

During the summer of 1911 and 1912, the writer was given the opportunity, by Dr. R. W. Brock, of visiting the Ordovician sections in the Lake Huron area under the auspices of the Canadian Geological Survey. During the first summer he was accompanied by Prof. Arthur M. Miller, who made a special study of the Mohawkian strata on Cloche and Goat islands, and in the vicinity of Little Current, and who gave him the benefit of his extended acquaintance with Mohawkian strata, especially in relation to the correlation of these strata as exposed in the Lake Huron area with those of Kentucky. During the summer of 1911, and during a part of 1912, he had also the assistance of Mr. E. J. Whittaker, of the Canadian Geological Survey, especially in his investigations of the Cincinnatian strata. Mr. Whittaker has since given special attention to the Cincinnatian strata in the vicinity of Meaford, and some of his observations are here incorporated. The notes here presented are merely preliminary to a more extended study of the field.

As will be noted on the following pages, the writer has had the frequent assistance of Dr. E. O. Ulrich, Mr. R. S. Bassler, Prof. Percy E. Raymond, Dr. Ruedemann, and others, in the interpretation of the fossil faunas. It will be readily recognized, however, that these investigators were at a disadvantage in not being able to examine the faunas themselves in the field, since the writer may have failed to collect some of the most valuable diagnostic fossils.

2. Basal Bed; Red Clay Shales; Lowville.

The oldest Ordovician rocks, in that part of Lake Huron which lies north of the eastern end of Manitoulin island, are exposed for a distance of several miles along the western shore of Cloche peninsula, facing Cloche channel. At the northern end of the line of exposure these oldest Ordovician rocks rest upon and against an east and west ridge of quartzite mapped by the Canadian Geological Survey as Huronian. They consist of reddish clay shales whose thickness is not known even approximately. At one locality, along a small gully, a vertical section, 60 feet thick, is exposed above lake level, whitish limestones making their appearance 70 feet above the lake, but the entire thickness of the red clay section probably is much greater. Fossils were found at only one horizon, at a locality about a mile south of the northwestern angle of the peninsula, where a few feet of more or less indurated, brownish, sandy layers are imbedded in the reddish clay section, a short distance above the level of the new line of railway now in the process of construction. Here a species of *Pterotheca*, closely allied to *Pt. attenuata* but only about 20 mm. in width, and a species of *Cyrtodonta*, 25 mm. long and closely related to *C. janesvillensis*, suggest the Platteville or Lowville age of the strata involved. Well preserved specimens of *Archinacella* and *Lingula* also occur.

3. Swift Current Beds; Chiefly Whitish and Reddish Limestones; Leray.

Along the southern half of Cloche peninsula, whitish limestones overlie the red clays. Owing to the southward dip of the strata, the base of this limestone series descends to water level more than a mile before reaching Swift Current, the locality at which the railroad passes from the peninsula over to Cloche island. The general color of these limestones is whitish, but where they rest upon the Huronian quartzites, and in the immediate vicinity of the quartzite hills, they frequently are reddish. This reddish color evidently is due to the material derived from the quartzites and other Huronian strata which had been greatly disintegrated by weathering before the deposition of both the basal red clays and of the Swift Current limestones began. A quarry recently opened at Swift Current, for the purpose of providing the ballast needed for the new line of railway, exposes beautifully the top of a quartzite knoll covered by some of the upper layers of this limestone section. Where these limestones are in contact with the quartzite they not only are reddish in color but they also include pebbles and smaller fragmental material, evidently derived directly from the quartzite knoll. Among this fragmental material occur most of the fossils so far collected, including a pygidium of *Bathyurus*, the sipho of *Actinoceras bigsbyi*, a *Rhyn-*

chotrema probably *Rh. ainsliei*, and a *Dalmanella* (*Pionodema*) belonging to the *subaequata* group. Among the bryozoans, Dr. E. O. Ulrich identified *Escharopora ramosa*, *Phyllodictya labyrinthica*, *Rhinidictya fidelis*, *Rh. nicholsoni*, *Rh. trentonensis*, and forms of *Rh. mutabilis* and of *Homotrypella instabilis*, suggesting relationship to the upper Platteville fauna of Minnesota and the Leray fauna of New York. This fauna is exposed also at a slightly higher geological horizon, immediately below the very fine grained "Birdseye" limestone, along the railroad about three quarters of a mile south of Swift Current. At a small quarried exposure along the same line of railway, but about a mile north of Swift Current, strands of some form of *Tetradium* occur, in the white limestones, which can not be identified with *T. cellulosum*.

The very fine grained, white, "Birdseye" limestone, at the top of the Swift Current limestone series, forms a convenient lithological means of separating this series from the overlying part of the Black river beds. It is well exposed at several localities within a mile going southward from Swift Current. Its thickness is about 11 feet. It is interbedded with a small amount of whitish clay, and contains but very few traces of fossils.

Lithologically, the "Birdseye" limestone at the top of the Swift Current limestone section resembles the Tyrone limestone as exposed in Central Kentucky. This resemblance was noticed by Prof. Arthur M. Miller, who was a member of the party in 1911, and who made a thorough study of the entire Mohawkian group, giving the writer the benefit of his extended experience. It is probable that the entire Swift Current limestone section is to be correlated with the Tyrone, but this can not be determined from the meager fauna at hand. The total thickness of this section is unknown. Fifty feet probably is a moderate estimate.

4. Cloche Island Beds; "Black River" Limestones.

With the exception of the northern line of out crops on Cloche island, and those in the vicinity of Swift Current already described, almost the entire surface of Cloche island is formed by those darker limestones between the Leray member of the Lowville at the base and the Trenton limestones at the top to which it frequently has been customary to confine the term Black river. In the lower part of this Cloche island phase of the Black river section, fine grained limestones alternate with coarser grained layers for a vertical distance of about 30 feet. These strata are overlaid by coarser grained limestones in which finer grained layers are not conspicuous, and which attain a thickness of about 50 feet. These strata are well exposed along the railroad within two miles going south from Swift Current. The total thickness of the Cloche island beds may equal 150 feet, but no locality was found where this could be determined.

The two most characteristic fossils of the lower part of the Cloche island beds are *Columnaria halli* and *Stromatocerium rugosum*. *Columnaria halli* ranges from the base of these beds to about 45 feet above the base. *Stromatocerium rugosum* was found about 20 feet above the base and may occur also at other levels in the lower part of these beds. It is evident that both *Columnaria halli* and *Stromatocerium rugosum* may be looked for in the underlying Swift Current limestones, since *Columnaria halli* occurs in the upper or Leray member of the Tyrone formation in Central Kentucky, and has been found also in the Lowville at Watertown, New York; while *Stromatocerium rugosum* is found in the Lowville northeast of Watertown, New York.

Receptaculites occidentalis begins its range about 20 feet above the base of the Cloche island beds; it becomes common at 55 feet above the base, where the first specimens of *Maclurea logani* are seen. No specimens of *Gonioceras anceps* were discovered within 80 feet of the base of these limestones, but they begin their range a short distance above this level, and all three species, *Receptaculites occidentalis*, *Maclurea logani*, and *Gonioceras anceps* extend to the extreme top of the section as exposed on Cloche island, but have not been found in the lowest Trenton layers found on Goat island, immediately southward. The presence of these fossils is therefore used here to discriminate the Black river from the overlying Trenton limestones. It should be remembered, however, that *Receptaculites occidentalis* has been identified by Ulrich from the Curdsville bed, in the lower Trenton of Kentucky, and species of *Maclurina*, which can not readily be distinguished from *Maclurea* in the field, occur in the Trenton of the northwestern states. Moreover, considering the very close similarity of the Curdsville fauna on Goat island to that found in the underlying Cloche island limestones, it would be rash to state that no *Gonioceras* ever will be found in the Curdsville. The chief point is that the great abundance of *Receptaculites*, *Gonioceras*, and *Maclurea* distinguishes the top of the Cloche island Black river limestones readily from the base of the lowest Trenton limestones found on Goat island.

Near the top of the Black river exposures on Cloche island, within a mile of the southwestern termination of that part of the railroad which crosses Cloche island, *Protarea vetusta*, *Calapoecia canadensis*, *Petraia aperta*, a large celled form of *Columnaria alveolata*, with more or less discrete and rounded corallites, 7 mm. in diameter, and a specimen doubtfully identified as *Eurystomites undatus* occur. Of these, *Protarea vetusta* has been recorded hitherto only from the lower Trenton, but the other four forms mentioned have so far not been recorded from the Trenton, and are regarded as characteristic Black river species or varieties.

Among other forms occurring in the Cloche island limestones may be mentioned *Rafinesquina inquassa*, *Dalmanella gibbosa*, and *Conradella obliqua*, all of which suggest Black river age. *Streptelasma profundum*, *Rhynchotrema* (?) *ottawaensis*, *Orthis tricenaria*, *Dinorthis pectinella*, a small *Dalmanella* belonging to the *testudinaria* group, *Strophomena filitexta*, *Plectambonites curdsvillensis*, *Leperditia fabulites*, *Bumastus milleri*, and numerous other species range from the Cloche island Black river limestones into the Curdsville strata, exposed at the base of the Trenton on Goat island. *Solenopora compacta*, *Herbetella bellarugosa*, and *Actinoceras bigsbyi*, hitherto not found above the Cloche island limestones, may eventually be found also in the Curdsville beds on Goat island, since they occur in the Trenton elsewhere. Not being familiar with Black river faunas, the writer submitted the fossils collected to Prof. Percy E. Raymond, and was pleased to receive his confirmation as to the Black river age of the Cloche island limestones.

The bryozoans were submitted to Dr. E. O. Ulrich, with the following results: *Batostoma humile*, *B. varium*, *B. winchelli*, *Eridotrypa mutabillis*, *Homotrypa minnesotensis*, *Nicholsonella ponderosa*, *Phyllodictya frondosa*, *Phylloporina sublaxa*, *Prasopora insularis* are represented by varieties also occurring in the Decorah shales of the Mississippi basin, and thus tend to corroborate the reference of the Cloche island beds to the Black river. As a matter of fact, *Batostoma winchelli* and *Homotrypa minnesotensis* were identified also from the Curdsville bed in the lower part of the Trenton on Goat island, and some of the other species, such as *Batostoma humile*, *Eridotrypa mutabilis*, and *Prasopora insularis*, are known to range upward into the lower Trenton, but, to Dr. Ulrich, this bryozoan fauna presented a distinct Decorah shale facies. Most of these bryozoans were collected in the upper part of the Cloche island beds, above the 80 foot level mentioned in the preceding lines. Further collecting may indicate the presence also of other faunas within these beds.

5. Curdsville and other Trenton Exposures on Goat Island.

The lowest exposures of the Trenton on Goat island present a fauna very similar to that of the underlying part of the Black river, excepting for the apparent absence of *Receptaculites*, *Maclurea*, *Gonioceras*, and a few other fossils, and the presence of the interesting crinoid and cystid fauna known from Curdsville, Kentucky, and from Kirkfield and other Trenton localities in Ontario. While a form of *Dalmanella* belonging to the *testudinaria* group, and *Plectambonites curdsvillensis* are present in these lower Trenton strata on Goat island, they occur also at various horizons in the underlying Cloche island limestones.

When Prof. Arthur M. Miller visited the exposures at the extreme northeastern end of the railway line crossing Goat island, he was impressed with the Curdsville facies of the fauna included. He found *Carabocrinus vancortlandi*, *Cleiocrinus regius*, and *Glyptocrinus ramulosus*, to which have been added more recently *Reteocrinus alveolatus* and *Cyclocystoides halli*, a typical Kirkfield fauna. Among the bryozoans collected at this horizon Dr. E. O. Ulrich identified provisionally *Batostoma winchelli*, *Bythopora* cf. *alcicornis*, *Callopora multitabulata*, *Eurydictya multipora*, *Homotrypa minnesotensis*, *Monticulipora* (?) *cannonensis*, *Rhinidictya minima*, and *Rh. mutabilis*. Apparently there is an admixture of Black river with Trenton species, but possibly the real explanation is merely the greater vertical range of various species hitherto not found above the Black river.

The total thickness of the strata to be assigned to the Curdsville bed is unknown. From the lowest strata seen on Goat island to the highest strata containing an abundance of the columns of *Glyptocrinus ramulosus*, the interval is nearly 30 feet. The *Carabocrinus vancortlandi* layer is about 7 feet above the base of this section, and most of the other crinoids and cystids occur about 11 feet above this level. *Stromatocerium* is rare in the layer immediately overlying the upper *Glyptocrinus* horizon, but becomes common at a higher horizon which is exposed along the southern margin of Goat island. Possibly 20 feet would be sufficient to cover this interval, and an equal interval might account for the strata intervening between this abundant *Stromatocerium* horizon along the southern edge of Goat island and the lowest strata exposed along the shore in the eastern margin of Little Current.

6. Trenton Exposures at Little Current, on Manitoulin Island, including Collingwood Formation.

Immediately at water's edge, east of Little Current, the following bryozoans were collected and submitted to Dr. E. O. Ulrich: *Arthoclema billingsi*, *Callopora multitabulata*, *Dekayella trentonensis*, *Eridotrypa mutabilis*, *Mesotrypa infida*, *M. cf. whiteavesi*, *Monticulipora arborea*, *Prasopora simulatrix*, and *Rhinidictya fidelis*. The fauna as a whole impressed Dr. Ulrich as resembling that in the *Nematopora* horizon in the upper Prosser. While some of the species are found also in the Wilmore, these are forms which occur also in the upper Prosser, while conversely no forms are seen here which occur only in the Wilmore. A small specimen of *Strophomena* and numerous specimens of *Rhynchotrema inaequivalve* occur at the same horizon.

If the abundant Trenton fauna found in the white limestones northwest of Collingwood, on the lake front, find any equivalent in the Mantoulin area, this must lie somewhere between 20 and 30 feet above the lake in the section exposed east of Little Current,

but no good exposures have been found. *Tetradium* bundles occur at 45 feet above the lake, and massive specimens are found 4 feet farther up.

The strata immediately above the *Tetradium* horizon consist of fissile black shales interbedded with limestone near the base. These strata were formerly regarded as Utica, but they probably represent an older formation than the Utica of New York, and recently Prof. Percy E. Raymond has proposed for them the name Collingwood. Their most characteristic fossil is the trilobite long known as *Asaphus canadensis. Triarthrus spinosus*, and a graptolite, identified by Dr. Ruedemann as *Diplograptus quadrimucronatus*, also occur. At Little Current, 11 feet of this Collingwood shale are exposed, but the total thickness may equal 20 feet.

7. Cincinnatian Beds on Manitoulin.

A. Sheguindah Beds; Eden.

Along the road from Little Current to Sheguindah, the strata immediately overlying the Collingwood formation are exposed at several localities. One of these extends from three miles southeast of Little Current southwards up the hill. Here the top of the Collingwood is overlaid by shales which near the base are blackish but much softer. Within 9 feet of the base, these clay shales contain a species of *Triarthrus*. A small *Primitia* and a *Leptobolus* extend from the base upward for about 37 feet. The only species of graptolite noted is fairly common, and was determined by Dr. Ruedemann as nearest to *Diplograptus peosta*, but with closer arranged thecæ; it ranges from the base for 43 feet upward. *Dalmanella* appears at 25, between 37 and 43 feet, and at higher levels. The first trace of limestone was found 43 feet above the base, but limestone layers do not become common until an elevation 100 feet above the base has been reached.

It is in these upper limestones and in the interbedded clays that the typical Eden fauna listed below occurs. The fossils were examined by Ulrich, Bassler, and Nickles conjointly, the determinations being only provisional, until microscopic slides can be prepared. Along the Sheguindah road, *Amplexopora persimilis, Callopora sigillarioides, Coeloclema communis, Hemiphragma whitfieldi, Perenopora vera*, and a *Stigmatella* near *clavis* or *nana* occur. From the corresponding strata at Tamarac Point, 10 miles southwest of Little Current, *Aspidopora* cf. *areolata, Arthropora clevelandi, Bythopora arctipora*, and *Primitia centralis* occur in addition to those already named. At the corresponding horizon at Gorrel Point, two miles northeast of Gore Bay, *Aspidopora eccentrica, Bollia persulcata, Bythocypris cylindrica, Jonesella crepidiformis, Primitia cincinnatiensis*, and *Acidaspis crossotus* are added to the list. At the exposures immediately south of the high Richmond Clay Cliffs, on the eastern side of Cape Smyth,

Dekayella ulrichi and some species of *Eridotrypa* is present. These fossils indicate the Eden age of the upper limestones in this Sheguindah section. The strata belong somewhere near the upper part of the Economy or the lower part of the Southgate section apparently. The thickness of this richly fossiliferous limestone and clay section may equal 20 feet, but only the lower 5 feet are well exposed along the Sheguindah road.

One hundred and twenty-seven miles southeast of Little Current, along Workman's brook, two miles east of Meaford, *Trinucleus bellulus* and *Callopora sigillarioides* are exposed about 4 feet above lake level, and this is the reason for including the lower clay shales in the same section as the upper undoubted Eden limestones. In the Workman brook section, the Eden limestones become common about 75 feet above lake level, and that part of the Eden section which lies above this level may equal 50 feet.

B. Wekwemikongsing Beds; Lorraine.

Overlying the undoubted Eden beds, there is a series of strata containing *Whiteavesia pholadiformis*, *Modiolopsis concentrica*, *Byssonychia radiata*, *Lyrodesma poststriatum*, *Clidophorus planulatus*, a large *Ctenodonta* belonging to the *pectunculoides* group, and a species of graptolite identified by Dr. Ruedemann as nearest to *Diplograptus angustifolius* mut. *vespertinus* from the Middle Lorraine of New York. In fact, the general aspect of these strata is Lorraine, since the lamellibranchs occur in siliceous limestones which weather into fine grained sandstones, as is the case in the typical Lorraine.

In the lower strata belonging to the Wekwemikongsing section, as exposed south of Little Current, Dr. Ulrich identified *Bythopora dendrina* and *Bythopora gracilis*. From a corresponding horizon at the base of the Wekwemikongsing section, immediately south of the Richmond Clay Cliffs, on the eastern side of Cape Smyth, he identified *Dekayia pelliculata* in addition to the species named. The most interesting list, however, was obtained along Workman's brook, east of Meaford, where, in the 25 feet of strata underlying the *Catazyga erratica* horizon, Dr. Ulrich identified *Callopora* near *dalei*, *Coeloclema* sp., *Dekayia appressa*, *Heterotrypa* cf. *inflecta*, *Leptotrypa ornata*, and *Perenopora compressa*. These bryozoans suggest the middle Maysville age of these strata below the *Catazyga erratica* horizon. Dr. Ulrich placed them at approximately the Bellevue horizon. The base of the Wekwemikongsing beds on Workman creek appears to be about 50 feet below the *Catazyga erratica* horizon.

The only bryozoans identified between the *Catazyga erratica* horizon and the base of the undoubted Richmond, with *Catazyga headi*, *Cyclonema bilix*, and *Strophomena planumbona*, 160 feet farther up, are *Stigmatella* cf. *nicklesi*, *Discotrypa* cf. *elegans*, and *Spatiopora aspera*, also suggesting Maysville age.

In Ohio, *Whiteavesia pholadiformis* and *Modiolopsis concentrica* come in at the base of the Fort Ancient division of the Waynesville bed, and continue to the top of the Waynesville, but they are represented by at least very similar forms even in the Liberty. Under these circumstances it was natural at first to regard these strata, on Manitoulin, which carry the *Whiteavesia pholadiformis* and *Modiolopsis concentrica* fauna as Richmond. However, the bryozoans submitted to Dr. Ulrich tell a very different story, and, until further evidence has been accumulated, it is regarded wiser to remove them from the Richmond column. For collecting purposes these beds are well exposed for a distance of about two miles along the shore between Wekwemikongsing and the Richmond Clay Cliffs on the eastern side of Cape Smyth. The total thickness of the Wekwemikongsing section on Manitoulin island may equal 100 feet in the Cape Smyth area.

8. Richmond Strata on Manitoulin Island.

C. Waynesville Beds, or Lower Richmond.

Overlying the Wekwemikongsing beds, with their Lorraine fauna, is a series of interbedded limestones and clay shales of undoubted Richmond age. At the base of these undoubted Richmond beds, *Hebertella insculpta*, frequently associated with *Catazyga headi*, is almost invariably present, and since *Hebertella insculpta* and *Catazyga headi*, on Manitoulin, are limited to the basal part of these beds, both fossils here serve as valuable diagnostic fossils. Associated with these fossils in the same layers occur: *Streptelasma rusticum*, *Columnaria alveolata*, *Protarea papillata*, *Rhombotrypa quadrata*, *Hebertella occidentalis*, *Platystrophia clarksvillensis*, *Strophomena huronensis*, *Rafinesquina alternata* very flat form, *Plectambonites sericea*, *Rhynchotrema perlamellosa*, *Zygospira modesta*, *Cyclonema bilix*, and *Pterinea demissa*. These associated fossils, however, are not confined to the *Hebertella insculpta* and *Catazyga headi* horizon but range upward for variable distances into the overlying Richmond.

The lower part of the Richmond, on Manitoulin, is by far the richest in fossil remains, and many species, especially among the brachiopoda, appear to be confined to this lower part. Between Gore Bay, Kagawong, and Little Current, a conspicuous coral reef, from one to three feet thick, containing *Columnaria alveolata* and *Calapoecia huronensis*, frequently is found between 35 and 45 feet above the base of the *Hebertella insculpta* horizon. It has been found that while most of the fossils which begin their range at or near the *Hebertella insculpta* horizon reach the *Columnaria* reef horizon, many of these species do not extend their range beyond this reef. Among the latter may be mentioned: *Protarea papillata*, *Constellaria polystomella*, *Rhombotrypa quadrata*, *Crania scabiosa*, *Rafinesquina* very flat form, *Plectambonites sericea*,

Strophomena huronensis, Str. nutans, Str. neglecta, Str. planumbona, Str. sulcata, Platystrophia clarksvillensis, Zygospira kentuckiensis, Helicotoma brocki, Spyroceras hammelli, and various gasteropods and lamellibranchs not as yet identified. A form closely allied to *Zygospira kentuckiensis* occurs in the fossiliferous horizons of the Queenstown shales in the area south of Georgian Bay.

Among the various species beginning their range in that part of the Richmond section which underlies the Columnaria reef, but extending also above the latter, may be mentioned: *Stromatocerium huronensis, Strephochetus richmondensis, Tetradium huronensis, Streptelasma rusticum, Columnaria alveolata, Calapoecia huronensis, Hebertella occidentalis, Rhynchotrema perlamellosa, Zygospira modesta*, and various gasteropoda and pelecypoda not identified.

That part of the Richmond section on Manitoulin which lies between the base of the *Hebertella insculpta* zone and the base of the rich *Columnaria* reef corresponds approximately to the upper part of the Waynesville bed, especially to that part to which the term Blanchester has been applied.

D. Kagawong Beds, or Upper Richmond.

Columnaria alveolata and *Calapoecia huronensis* have a considerable vertical range, but the horizon at which they occur in sufficient abundance to form a conspicuous reef evidently is an important paleontological horizon, since it marks the disappearance of a considerable part of the underlying Richmond fauna. Moreover, it appears also to be at or above this horizon that *Beatricea undulata, Columnaria calycina*, and various thick-walled gasteropoda, such as *Liospira helena*, a large *Bellerophon*, and a large *Bucania* or *Salpingostoma* come in. These species are apparently such forms as could stand rough waters.

In general, the fauna in the strata immediately above the *Columnaria* reef appears to be a meager one. At least very few species have been listed from this zone excepting such forms as *Hebertella occidentalis, Rhynchotrema perlamellosa*, and *Zygospira modesta*, which appear to be able to survive under very adverse conditions.

At one locality, on an east and west road three miles south of Little Current, *Strophomena vetusta* and *Ceraurus* (*Eccoptochile*) *meekanus* occur just above this *Columnaria* reef. These fossils suggest the upper Liberty or the Whitewater age of the strata involved, while the great abundance of the *Columnaria alveolata*, and of *Calapoecia huronensis*, accompanied by *Beatricea undulata*, suggest the Saluda age of the same strata. In either case, the horizon is distinctly above that of the Waynesville of Ohio.

Another conspicuous zone, between Gore Bay, Kagawong, Honora, and Little Current, is a *Stromatocerium* reef which usually is found between 25 and 30 feet above the *Columnaria* reef, but

which occurs eastward at greater intervals. It is the interval between these two reefs which usually presents such a meager fauna. Locally, however, for instance between Manitouaning and Cape Smyth, the lower parts of this section appear richly fossiliferous.

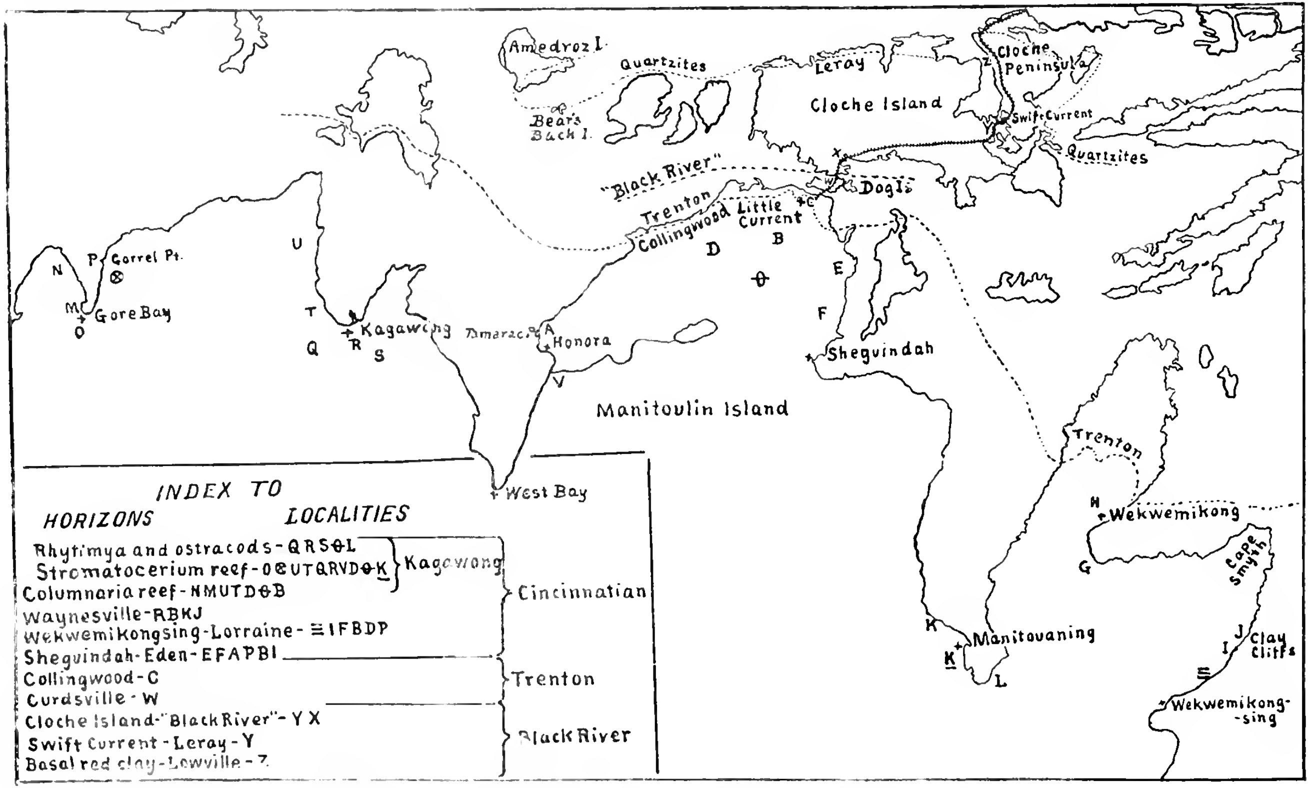
Immediately above the *Stromatocerium* reef, at Kagawong and Gore Bay, a rich pelecypod, gasteropod, and ostracod fauna, but not consisting of many species, comes in. Among these, *Ortonella hainesi* suggests the Whitewater age of the strata involved, while *Leperditia cæcigena* and *Primitia lativia* are common at certain horizons in the Saluda of Indiana but range to the top of the Elkhorn in Ohio. *Cyrtodonta ponderosa*, *Ctenodonta iphigenia*, a large *Archinacella*, and various species of *Lophospira* occur. Among the species which continue their range upward from below are *Strephochetus richmondensis*, *Tetradium huronensis*, *Hebertella occidentalis*, *Zygospira modesta*, *Byssonychia radiata*, and *Pterinea demissa*. They are all forms capable of continuing existence in muddy waters, judging from the frequency with which they are found in argillaceous limestones, fine grained sandstones, and clays. The total thickness of this upper part of the Richmond, from the *Stromatocerium* reef to the base of the Clinton, varies apparently from 45 to 60 feet, on Manitoulin.

E. Queenstown Shales.

The northwestern extension of the red clay shales, to which the term Queenstown has been applied in the Niagara Falls area, is well exposed on the Saugeen peninsula which separates Georgian Bay from the main body of Lake Huron. In the vicinity of Collingwood, Meaford, Owen Sound, and westward, these red shales evidently represent the strata above the Columnaria reef horizon as exposed on Manitoulin. The only fossiliferous strata found in these Queenstown shales, however, belong to those horizons above the *Stromatocerium* reef in which ostracods are abundant. In addition to *Leperditia cæcigena* and *Primitia lativia*, *Eurychilina striatomarginata* and *Drepanella canadensis* are present, accompanied by the Richmond form of *Bythocypris cylindrica*, *Byssonychia radiata*, *Pterinea demissa*, a *Zygospira* resembling *Z. kentuckiensis*, *Bythopora delicatula*, and other characteristic Ordovician fossils.

At the Forks of the Credit, 65 miles southeast of Meaford, no trace of this Richmond fauna was found anywhere in the Queenstown red clay shale section.

In the vicinity of Meaford, the highest layers of the Richmond fauna occur fully 100 feet above the top of the richly fossiliferous Waynesville fauna at the base. The total thickness of the Queenstown shales, in the vicinity of the Niagara Falls, however, is estimated at 1000 feet, so that it may be only the basal part of the Queenstown shale which is of Richmond age, although there appears no lithological reason for imagining a different age for the upper part of the Queenstown section.



FOERSTE "On the Ordovician Section in the Manitoulin Area of Lake Huron."

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INDUCED MODIFICATIONS IN PIGMENT DEVELOPMENT IN SPELERPES LARVAE.*

(Preliminary Paper)

A. M. BANTA and ROSS AIKEN GORTNER.
(From the Station for Experimental Evolution, The Carnegie Institution of Washington.)

INTRODUCTION.

We present here a brief account of a series of experiments having as their aim the inhibition, or the modification of pigment development.

We believe that it is a fairly well established fact that the black melanic pigment results from the interaction of an oxidizing enzyme of the tyrosinase type and some oxidizable chromogen, the exact nature of which has never been elucidated†. One of us, (Gortner 1911, b,) has shown that certain organic phenols inhibit the action of tyrosinase in the test tube and the suggestion was made that perhaps certain types of colorless animals owe their lack of pigment to the presence of inhibitory compounds. The present series of experiments was carried out in order to test the inhibitory powers of the *m.* di-hydroxy phenols *in vivo* as contrasted with their action *in vitro.*

The material upon which the experiments were carried out, consisted of eggs and embryos of the salamander, *Spelerpes bilineatus,* Green. This material is unusually suitable for such work inasmuch as the eggs contain no pigment when deposited, and the early stages of pigmentation in the embryo can thus be followed from day to day.

* Presented at the annual meeting of the Ohio Academy of Science, Columbus, Nov. 30, 1912.

† For literature see Kastle (1910), Riddle (1909), and Gortner (1911, a).

By macerating larvæ which were about to begin pigmentation and adding tyrosin to the aqueous extract of the crushed larvæ, we observed the color changes which are characteristic of tyrosinase. We have also satisfied ourselves that the onset of pigmentation in the Spelerpes larvæ is due to the beginning of chromogen secretion, the tyrosinase having been already present for some time.

Experimental.

Our experimental data groups itself under four heads: (1), Experiments with Tyrosin; (2), Experiments with Orcinol, (3. 5. di-hydroxy toluene); (3), Experiments with Resorcinol, (*m.* di-hydroxy benzene) and (4), Experiments with Phloroglucinol, (*sym.* tri-hydroxy benzene).

Experiments with Tyrosin.

This series comprised 41 experiments (not including an equal number of checks) and a total of 428 individuals. The checks in every case came from the same bunch of eggs and were kept under the same conditions as the tyrosin-treated lot with the exception that no drugs were used. What is true of the tyrosin checks is also true in the checks of all the subsequent experiments. Owing to the slight solubility of tyrosin (one part in 2454 parts of water at 20°) it was impossible to test the effect of high concentration. Twenty experiments, comprising 208 individuals showed no marked effect of the tyrosin, *i. e.* they were usually indistinguishable from the corresponding checks. We find however that in 11 of these experiments the tyrosin was of a lower concentration than 0.008% and below this concentration we have succeeded in but one case (0.006%) in producing an effect and in this one case the larvæ "reverted" to normal after 28 days. Six of the remaining nine experiments which showed no effect are shown by our records to have been "poisoned", either by confinement in too limited quarters or by bacterial infection. The checks of those which were confined in too small dishes (small stender dishes) showed the same abnormal traits that were observed in the treated material. Of the remaining three experiments which failed to show a marked effect, two were in tyrosin of 0.025% concentration and the remaining lot in 0.010% tyrosin. The former showed some influence for a time but later "reverted." The other showed no influence.

Twenty-one experiments, comprising 220 individuals were profoundly influenced by the tyrosin treatment and became "good" or "typical" tyrosin types. The tyrosin influence is shown by; (1), The more rapid appearance of pigment in the treated lot as contrasted with their checks; (2), The extremely small size and later the entire absence of pigmentless spots in the larvæ, the spaces where spots are normally visible being filled

with dense black pigment; and (3), the dense dull-black color of the larvæ compared with which the check often appears very light.

There is no mistaking the "tyrosin type", for an inexperienced person will always pick them out as the darkest individuals in a series.

Of the 21 experiments which showed an effect, 15 had a tyrosin concentration of 0.010%, 1 of 0.0125%, 2 of 0.020%, 1 of 0.040%, and 1 of 0.006% (this last being the only one of the entire 41 experiments which showed an effect at this concentration, and which, as noted above, "reverted" after the 28th day).

The time of treatment averages about 60 days, and in three experiments (Nos. 560, 595, 609) which are still running (Dec. 6) the larvæ were in tyrosin for 72 days and have since been in pure water only (no tyrosin) for 123 days. They are still appreciably darker than the corresponding checks, and show enough of the characteristics of the "tyrosin type" to be readily classified as such. During the later period the larvæ have at least doubled their previous length, but it is impossible to say whether their continued darker color is due to a continued more active pigment formation or merely to a distribution over a larger area of the dense black mass of pigment already present†.

Experiments with Orcinol.

Orcinol, as noted above, inhibits the action of tyrosinase upon tyrosin in the test tube, and we hoped to be able to inhibit, or at least to modify, the course of pigment development by rearing the larvæ in solutions of orcinol. We found the drug to be quite toxic, not so much so of itself as the oxidation products which are formed by the action of light upon a solution of orcinol. However, by changing the solutions every day, or every second day, and keeping the dishes, together with the controls, in a dimly lighted room, we were able, in part, to prevent the toxic action. In this manner we have been able to keep larvæ in a solution of 0.020% concentration for 50 days.

Altogether 35 experiments were run, including 513 individuals (not including checks). Later it seemed advisable to subdivide some of the experiments so as to accurately test the effect of varying length of immersion in the drug solution. A total of 115 such removals were made, each one in reality being a separate experiment in itself, thus making a grand total of 150 experiments. Concentrations of orcinol ranging from 0.0125% to 0.025% were employed.

† As the larvae become older the characteristic spots of the checks become less conspicuous and are later lost so that the types become less differentiated, and the depth of color is about the only criterion available at this stage of development.

To briefly summarize the effect; we obtained, *in every instance*, a retardation of growth accompanied by a much greater retardation in pigment development than would correspond to the retardation in growth. In some experiments where the concentration of the orcinol was very low and where the length of the immersion was short we did not obtain permanent after-effects and the later course of development resembled that in the checks. When, however, the strength of the orcinol was sufficiently high (0.020% to 0.025%) and the period of treatment sufficiently long, varying from one day to a week or more depending upon the initial age of the embryo, we have apparantly obtained permanent modifications. The nature of these effects depends to some extent upon the initial age of the egg or embryo. When eggs at a stage of development between the early blastula and late neural groove are kept in the solution less than six days they rarely show as abnormal types as those which have been exposed to the action of the drug for from 6 to 20 days. They do show, however, the typical retardation of pigment development, and various other characteristics (see below) sufficient to classify them as "orciny."

Where these early embryos are kept in the solution more than six days, the course of development is decidedly different. The larva developes in many cases apparently normally though somewhat slowly, until within a short time before hatching, or in some cases for several days after hatching, when huge swellings appear, sometimes filling the entire body with great serous cavities, through the walls of which may be seen the alimentary canal and blood vessels, stretched almost to breaking. In this condition they may live for days, but eventually die without further development.

If, however, the embryos are older when treated—*i. e.* with the head strongly differentiated or at any later stage to the beginning of pigmentation (which occurs shortly before hatching)—the effect is widely different. In no instance do we obtain the blistered larvæ, but instead, short heavy individuals, about one-third shorter and twice as broad as the checks. These animals we class as the true "orcinol type". They are distinguished from the checks by their shorter length, greater girth, absence of any conspicuous spots, the development of heavy awkward "flippers" in the place of delicate limbs and toes, the coarse reticulation of the pigment pattern, their sluggish movements, and, what is most disappointing, their inability, or at least their disinclination, to take food. This last trait prevents our knowing how permanent the type may be, the better orcinol examples (which were numbered by the dozens) having, without exception, grown smaller and at last died, apparently of starvation, in an average of eight to nine weeks after hatching. A few of the less extreme types are still alive (Dec. 6) 161 days after removal from the solutions, and in almost every instance the coarse reticulations and the heavier body form still persist.

Experiments with Resorcinol.

A total of 150 experiments, including 103 which had as their aim the test of the effect of varying length of immersion in the drug, were conducted using 636 larvæ, not including checks in each series. We find that resorcinol is more potent than orcinol, not alone in being more toxic, but the type produced by it is, if possible, more definite. The same swellings of the serous cavities are produced if the eggs are treated before reaching the late neural groove. When treated before reaching the blastula, no larvæ were hatched.

When larvæ which had the head strongly differentiated or were in any stage between this and a day or two after the beginning of pigmentation, were treated with resorcinol in sufficient concentration (0.020% to 0.025% and in one instance 0.05%) and for a sufficient length of time (4 to 10 or more days) they were highly modified and produced one of two types. Both types begin with a retardation of development and a great retardation of pigmentation. The first pigment appears in the eye and in a day or two a narrow V appears on the shoulders, followed a little later by a narrow line down the spine. *This condition persists as long as the larvæ remain in the resorcinol*, but unfortunately the drug is so toxic that 15 to 18 days immersion invariably causes death. We have had many instances where the larvæ which were treated with resorcinol appeared almost entirely devoid of pigment except for the dark eyes, when the corresponding checks were completely pigmented and the spots were fully developed.

When the larvæ are removed from the resorcinol solution after varying lengths of time we obtain the same two types referred to above. The more extreme type (See Fig. No. 1) resembles the "orcinol type" but is heavier, the "flippers" are more enlarged, and the pigment reticulation is very fine as contrasted with the coarse reticulations of the orcin type. This type persists for 60 to 70 days when death by starvation ensues.

The second type probably represents those individuals which have not been so profoundly modified. The body form is almost normal, the limbs and toes are well developed, but the spots are absent and the pigment pattern is very fine and dull in color. The majority of this type also die of starvation, and on Dec. 6—about 161 days from the beginning—we have only a very few individuals remaining. None of these have been "typical" but have been classed as "fair resorcin" or "somewhat modified" and all but two of these larvæ still show modification. At this period of development, however, the checks have lost their characteristic markings so that a closer analysis is impossible. In nearly every instance in both the orcinol and resorcinol series, the surviving individuals are lighter than the checks.

Experiments with Phloroglucinol.

From the position of the hydroxyl groups we expected to find that phloroglucinol caused greater effects than orcinol. In a series of 20 experiments comprising 174 individuals we find that no retardation occurs, providing that oxidation by light is prevented. On the contrary, a slight *acceleration* of pigmentation takes place and the spots are almost invariably larger and more distinct throughout the entire course of development. Beyond this, and an apparent slight stimulation in growth, no effects have been noted. The drug was employed in a strength of 0.025%.

SUMMARY.

By subjecting the eggs and larvæ of *Spelerpes bilineatus* to the action of dilute solutions of tyrosin, orcinol, resorcinol and phloroglucinol, we have observed the following effects on the general development, and in particular on the development of the pigment pattern:

(1). Tyrosin causes an acceleration of pigment development and later produces larvæ which differ from the check by the absence of spots, and the presence of a much more dense deposition of pigment.

(2). Orcinol, when applied for six or more days to embryos younger than the late neural groove causes monstrosities. When used with embryos at a later period of development it causes the body to become short and thick, the spots to become irregular or wholly absent, the entire color pattern to be blurred, the general character of the pigment pattern to be a coarse reticulation, the limbs to become "flippers", and the larvæ to be unable, or disinclined, to take food.

(3). Resorcinol causes much the same modifications as orcinol, with the exception that the pigment reticulation is very much finer. A second resorcinol type does not show the abnormal body form.

(4). Phloroglucinol causes no abnormalities, and when any result is to be noted it is the more distinct markings of the color pattern and a slight acceleration of pigment development.

(5). All of these modifications are persistent for weeks after removal from contact with the drugs, and to all appearances the orcinol and resorcinol types would be permanent were it possible for the larvæ to take food.

The work is being continued.

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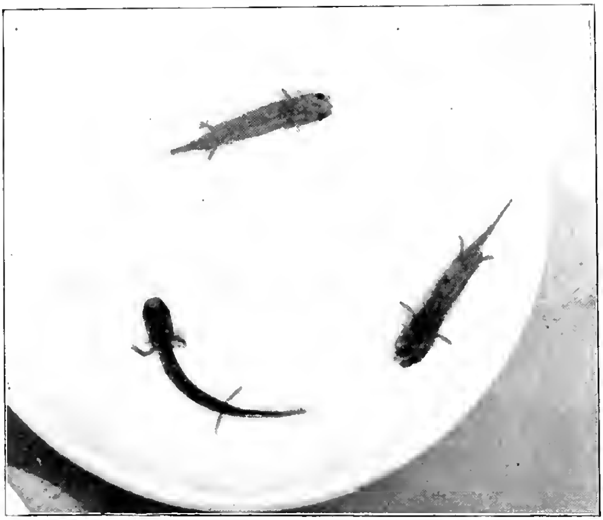

FIGURE 1.

Photo from life (x 2.3) of two Spelerpes larvae which were kept in 0.05% resorcinol for seven days, beginning just before pigmentation started. Their heavy form and the peculiar pigmentation readily distinguish them from the accompanying check. The photograph was taken thirty days after the larvae were removed from the resorcinol solution.

THE VIOLETS OF OHIO.

Rose Gormley.

The following list includes all of the violets known to occur in Ohio. It is probable, however, that a number of others occur in the state. The distribution given is based on material in the Ohio State Herbarium. In this list an attempt has been made to arrange the species in true phyletic series, the least specialized in each group standing at the beginning and the most highly specialized at the end.

Violaceæ.

Small herbs, with bisporangiate, hypogynous, zygomorphic, axillary, nodding flowers and alternate, simple or lobed stipulate leaves. Sepals, petals and stamens 5 each; anthers erect, introrse, connivant or synantherous; ovulary of 3 carpels, unilocular with 3 parietal placentæ; lower petal enlarged usually with a spur; fruit a loculicidal capsule; seeds anatropous, with endosperm, embryo straight.

1. Sepals not auricled, stamens united, petals nearly equal. *Cubelium.*
1. Sepals more or less auricled at the base, stamens distinct, lower petal spurred. *Viola.*

Cubelium.

Perennial, erect, leafy stemmed herb, the leaves, entire or obscurely dentate; small greenish flowers, one to three together in the axils, petals nearly equal, the lower somewhat gibbous; anthers sessile, completely united into a sheath, glandular at the base. A monotypic genus of North America.

Cubelium concolor. (Forst) Raf. Green Violet. Plants 1—2½ ft. high, hairy; leaves 2—5 in. long, entire, pointed at both ends. Auglaize, Belmont, Brown, Clermont, Fairfield, Franklin, Hamilton, Lake, Licking, Noble, Pike, Shelby, Warren Co.

Viola.

Herbs with aerial leafy stems, or geophilous stems; flowers solitary or rarely 2 in the axils, early flowers petaliferous, often sterile, usually succeeded by apetalous, cleistogamous flowers which produce abundant seed; the two lower stamens bearing spurs which project into spur of the odd petal; capsules, three valved, elastically dehiscent.

Synopsis.

AERIAL LEAFY STEMS.

1. Style capitate, beakless, bearded at the summit; petal spur, short; stipules entire; flowers, yellow or whitish, sometimes tinged with violet.

1. Viola canadensis.
2. Viola scabriuscula.
3. Viola pubescens.
4. Viola hastata.

2. Style slender, not capitate; spur at least twice as long as broad; stipules somewhat herbaceous, fringetoothed; flowers white, cream-colored or violet.

5. Viola striata.
6. Viola labradorica.
7. Viola rostrata.

3. Style much enlarged upward into a hollow globose structure with a wide orifice on lower side; stipules leaf-like, large deeply cut or pinnatifid.

8. Viola rafinesquii.
9. Viola tricolor.

UNDERGROUND STEMS.

4. Rhizomes long and slender, usually producing runners or stolons; flowers yellow, white or violet; style dilated upward in a vertical plane, capitate with conical beak on the lower side.

10. Viola odorata.
11. Viola rotundifolia.
12. Viola lecontiana.
13. Viola blanda.
14. Viola lanceolata.

5. Rhizome fleshy and thick without runners; petals violet blue to purple; style dilated upward in a vertical plane, capitate with conical beak on the lower side.

15. Viola obliqua.
16. Viola papilionaceae.
17. Viola hirsutula.
18. Viola sororia.
19. Viola palmata.
    Var. 1. Viola palmata dilatata.
20. Viola pedatifida.
21. Viola emarginata.
22. Viola fimbriatula.
23. Viola sagittata.

6. Rhizome short, erect, not scaly; leaves divided; style clubshaped, beakless, obliquely concave at the summit; stigma with a small protuberance near the center of the cavity.

24. Viola pedata.

Key to the Species.

1. With leafy aerial stems; flowers axillary. 2.
1. Stems geophilous, sometimes stoloniferous; flowers appearing scapose. 9
2. Stipules entire; style capitate, beakless, bearded at the summit; flowers yellow or white with purple veins. 3.
2. Stipules sharply dentate, serrate or lacinate, much smaller than the leaf-blade; style, slender; flowers cream-colored, white, blue or purple; spur at least twice as long as wide. 6.
2. Stipules deeply divided, leaf-like, nearly as large as blade; style much enlarged upward into a globose hollow summit; annual or biannual. 8.
3. Flowers yellow. 4.
3. Flowers white with purple veins; leaves cordate-ovate, long pointed; plants tall. *V. canadensis* (1)
4. Leaves more or less hastate, those of the stem usually near the tip; flowers yellow. *V. hastata* (4).
4. Leaves not hastate; borne along whole length of the stem. 5.
5. Plant pubescent or villous. *V. pubescens* (3).
5. Plant glabrate or sparsely pubescent. *V. scabriuscula* (2).
6. Spur about half the length of petals or less; flowers white, cream-colored, pale blue or violet. 7.
6. Spur as long as petals or longer, slender; flowers pale violet veined with purple. *V. rostrata* (7).
7. Stipules very large, more or less lacinate, ½–1 in. long; petals white or cream-colored, with purple veins. *V. striata* (5).
7. Stipules small, dentate or serrate, ¼–½ in. long; flowers light blue or purple. *V. labridorica* (6).
8. Flowers ½–1 in. broad, variously colored with yellow, white and purple; plants rather robust and spreading. *V. tricolor* (9).
8. Flowers ¼–½ in. broad, bluish white to cream-colored; plants tall and slender. *V. rafinesquii* (8).
9. Style ending in a small hook pointing downward, not plug shaped or capitate; flowers deep violet purple (sometimes white), fragrant; introduced species. *V. odorata* (10).
9. Style club shaped, capitate, or dilated upward, beakless or with a conical beak on the lower side; native species. 10.
10. Leaves merely crenate or dentate or incised at the base, not lobed. 11.
10. Leaves mostly lobed or parted; in ours, flowers blue or violet. 21.
11. Flowers yellow or white; plants stoloniferous. 12.
11. Flowers blue or violet, plants not stoloniferous. 15.
12. Flowers yellow; style enlarging upward abruptly, capitate, beakless. *V. rotundifolia* (11).
12. Flowers white, stigma with a conical beak. 13.
13. Leaves cordate-ovate to orbicular. 14.
13. Leaves lanceolate to linear-lanceolate. *V. lanceolata* (14).
14. Upper and lateral petals three times as long as broad; petioles usually red-spotted. *V. lecontiana.*
14. Upper and lateral petals twice as long as broad; petioles not spotted. *V. blanda* (13).
15. Leaves of the cordate type, sometimes more or less ovate or reniform. 16.
15. Leaves of the ovate lanceolate, ovate or sagittate type, sometimes incised at the base. 19.
16. Plants essentially glabrous. 17.
16. Plants more or less pubescent. 18.
17. Leaves cordate-ovate, attentuate at the apex, very thin. *V. obliqua* (15)
17. Leaves ovate to reniform, obtuse or merely acute at the apex, thick. *V. papilionaceae* (16).

18. Spurred petal glabrous; flowers, violet to lavender. *V. sororia* (18).
18. Spurred petal with scattered hairs; petals reddish purple. *V. hirsutula* (17).
19. Leaves ovate or ovate-lanceolate not incised at the base. *V. fimbriatula* (22).
19. Leaves sagittate or ovate-sagittate, incised or deeply dentate toward the base. 20.
20. Leaves sagittate-lanceolate or ovate-sagittate; basal lobes often dilated and incised. *V. sagittata* (23).
20. Leaves deltoid sagittate, sharply dentate below the middle. *V. emarginata* (21).
21. Leaves sagittate-lanceolate or ovate-lanceolate in outline, only slightly lobed at the base. *V. sagittata* (23).
21. Leaves ovate or orbicular in outline usually deeply lobed or dissected. 22.
22. Lateral petals bearded; stigma with a conical beak on the lower side. 23.
22. Lateral petals not bearded; style club-shaped and beakless; stamen tips conspicuous orange. *V. pedata* (24).
23. Plants more or less pubescent; leaves mostly 3–9 lobed. *V. palmata* (19).
23. Plants glabrous or only slightly pubescent; leaves pedately divided into linear lobes. *V. pedatifida* (20).

1. **Viola canadensis** L. Canada Violet. Stem leafy, 4—16 in. high; leaves cordate-ovate, acute, serrate 1—4 in. long, $\frac{7}{8}$—$3\frac{3}{8}$ in. broad; stipules small, lanceolate, entire; flowers, pale violet or white with purple veins, lateral petals bearded. Lake, Medina, Columbiana, Jefferson, Coshocton, Belmont, Gallia, Muskingum, Fairfield, Clermont, Hamilton, Huron Co.

2. **Viola scabriuscula** (F. & G.) Schw. Smooth Yellow Violet. Plant 3–11 in. high; stems thick and leafy; leaves $1\frac{1}{4}$–$2\frac{1}{8}$ in. long, 1–2 in. broad, reniform to cordate-ovate, acute crenate-dentate; stipules, small, entire; flowers pale yellow. Common in Ohio.

3. **Viola pubescens.** Ait. Hairy Yellow Violet. Plant 6–16 in. high, hairy; leaves ovate or reniform, acute, crenate-dentate, $1\frac{1}{4}$–$2\frac{1}{2}$ in. long, 1–2 in. wide, petioles very short; flower yellow, purple veined with short spur and lateral petals bearded; capsule $\frac{1}{4}$–$\frac{1}{2}$ in. long, glabrous or wooly; stipules ovate, entire. Ashtabula, Lake, Medina, Stark, Wayne, Huron, Richland, Crawford, Ottawa, Wood, Hancock, Wyandot, Morrow, Hardin, Franklin, Fairfield, Warren and Pike Co.

4. **Viola hastata.** Michx. Halbert-leaf Violet. Stem slender, erect, leaves and flowers borne near the top, 2–7 in. tall; leaves short petioled, hastate to hastate-ovate, slightly serrate, acute 1–$2\frac{3}{8}$ in. long, $\frac{5}{8}$–$1\frac{7}{8}$ in. broad; flowers yellow. Lake, Cuyahoga, Portage, Columbiana, Belmont Co.

5. **Viola striata.** Ait. Striped Violet. Plant 3–22 in. high, stem slender, leafy; leaves heart-shaped, crenate-dentate, sometimes acute, $\frac{5}{8}$–$2\frac{3}{8}$ in. long, $\frac{1}{2}$–$1\frac{5}{8}$ in. wide; stipules, large, oblong, lanceolate, attentuate, $\frac{1}{2}$–1 in. long; flowers white with thick spurs, somewhat shorter than petals. Common in Ohio.

6. **Viola labridorica**. Schrank. American Dog Violet. Plant 4–7 in. tall, stems slender, numerous, glabrous; leaves somewhat hispidulous above, rounded at the apex, $\frac{3}{8}$–$1\frac{3}{8}$ in. long, $\frac{5}{8}$–$1\frac{3}{8}$ in. wide; stipules lance-linear, narrow $\frac{1}{4}$–$\frac{1}{2}$ in. long; flowers deep or pale violet, spur rather long, not so long as petal, but rather thick. Lucas, Lorain, Portage, Trumbull, Wyandot Co.

7. **Viola rostrata.** Pursh. Long-spurred Violet. Plant $1\frac{1}{2}$–7 in. high, compact, low, leaves round, heart-shaped, glabrous $\frac{5}{8}$–$1\frac{3}{4}$ in. long, $\frac{1}{2}$–1 3-16 in. broad; stipules narrow lance-linear $\frac{3}{8}$–$\frac{1}{2}$ in. long; flowers lilac with deep violet along the veins, spur as long as petal. Hancock, Cuyahoga, Lorain, Medina, Wyandot, Crawford, Wayne, Auglaize, Franklin, Licking, Perry, Jackson, Belmont, Jefferson, Columbiana, Trumbull Co.

8. **Viola rafinesquii.** Greene. Wild Pansy. Plant very slender, 3–15 in. high; leaves, earliest sub-orbicular, later obovate to linear lanceolate, attentuate at the base, $\frac{3}{4}$–$1\frac{5}{8}$ in. long, $\frac{1}{8}$–$\frac{1}{2}$ in. wide; flowers bluish-white to cream-colored; stipules, very large, leaf-like $\frac{5}{8}$–$1\frac{1}{2}$ in. long. Ottawa, Erie, Cuyahoga, Lake, Ross, Tuscarawas, Franklin, Pike, Miama, Montgomery, Hamilton Co.

9. **Viola tricolor**. L. Garden Pansy. Plant more robust than rafinesquii; lower leaves ovate, upper leaves longer than broad, crenate, $\frac{1}{2}$–$\frac{7}{8}$ in. long, $\frac{1}{4}$–$\frac{1}{2}$ in. wide; stipules large, leaf-like, $\frac{3}{4}$–1 in. long; flower variously, colored purple, white and yellow. Cuyahoga Co.

10. **Viola odorata** L. Sweet Violet. Plant, low, stoloniferous; leaves round or broadly ovate, cordate, obtuse, crenate, $\frac{5}{8}$–$1\frac{1}{4}$ in. long, $\frac{5}{8}$–$\frac{3}{4}$ in. broad; flowers deep purple, $\frac{1}{2}$–$\frac{5}{8}$ in. wide, very fragrant. Franklin, Lake Co.

11. **Viola rotundifolia** Michx. Round-leaf Violet. Plants low, bases of former leaves persistent on rootstock; leaves ovate or heartshaped, yellowish green, lighter below, $\frac{7}{8}$–$2\frac{3}{8}$ in. long, $\frac{5}{8}$–$2\frac{1}{8}$ in. wide, flowers yellow, lateral petals bearded, keel and lateral petals streaked with brown. Ashtabula, Cuyahoga, Hocking Co.

12. **Viola lecontiana** Don. Woodland White Violet. Leaves, bright green above, paler below, petioles red-spotted, blades orbicular to heart-shaped, 1–$2\frac{3}{4}$ in. long, 1–$2\frac{1}{4}$ in. wide; flowers white, fragrant. Hancock, Fairfield, Vinton, Cuyahoga Co.

13. **Viola blanda** Willd. Sweet White Violet. Plant, glabrate, somewhat stoloniferous from a very slender rootstock; leaves $\frac{1}{2}$–$1\frac{1}{2}$ in. long, $\frac{3}{8}$–$1\frac{1}{2}$ in. wide, thin, light green, reniform to orbicular; flowers, white. Ashtabula, Cuyahoga, Summit, Stark, Columbiana, Belmont, Knox, Licking, Fairfield, Hocking, Champaign, Franklin, Lucas Co.

14. **Viola lanceolata** L. Lance-leaf Violet . Leaves glabrous, lance-shaped, crenulate, $\frac{5}{8}$–2 in. long, 3-16–$\frac{3}{8}$ in. wide; flowers, sepals lanceolate, acute, keel petal white with purple stripes, lateral petals beardless. Fairfield and Lake Co.

15. **Viola obliqua.** Hill. Thin-leaf Blue Violet. Plant often solitary; leaves dark green, petioles 2–6 in. long, blades cordate, ovate crenate-dentate $\frac{7}{8}$–$2\frac{1}{4}$ in. long, $\frac{3}{4}$–$2\frac{1}{4}$ in. wide; flowers pale blue. General in distribution.

16. **Viola papilionaceæ** Pursh. Common Blue Violet. Plants robust; leaves sometimes deltoid, cordate, pointed or rounded, 1–5 in. broad, $\frac{5}{8}$–5 in. long, petioles $1\frac{3}{4}$–13 in. long, flowers deep violet, white or greenish yellow at base, sometimes wholly white; capsules ellipsoid to cylindric, green or dark purple. General in distribution.

17. **Viola hirsutula.** Brain. Southern Wood Violet. Plants low; leaves reniform to cordate, crenate $\frac{3}{8}$–$2\frac{1}{2}$ in. long, $\frac{3}{8}$–2 in. wide; flowers violet purple, lateral petals bearded, spurred petal with scattered hairs. Hocking, Fairfield Co.

18. **Viola sororia** Willd. Entire-leaf Blue Violet. Leaves pubescent, cordate to ovate, crenate-dentate, $\frac{5}{8}$–$1\frac{3}{4}$ in. long, $\frac{5}{8}$–$1\frac{1}{2}$ in. wide, petioles $1\frac{1}{2}$–6 in. long; flowers violet to lavender, spurred petal glabrous. Lake, Wood, Warren, Blemont Co.

19. **Viola palmata**. L. Palmate Blue Violet. Leaves cordate or ovate in outline, 1–3 in. long, $\frac{7}{8}$–$3\frac{3}{8}$ in. wide, with 3–9 lobes; flowers from pale to deep blue, $\frac{1}{2}$–$1\frac{1}{4}$ in. broad. Fulton, Wood, Lorain, Cuyahoga, Trumbull, Columbiana, Crawford, Licking, Fairfield, Clermont, Delaware, Darke, Preble, Wyandot, Franklin, Miami Co.

1. Var. **Viola palmata dilatata** Ell. Three-lobed Blue Violet. Leaves mostly three lobed, middle lobe ovate, outline of leaves usually hastate. Lake, Carroll, Knox, Auglaize, Vinton Co.

20. **Viola pedatifida.** Don. Larkspur Violet. Plant pubescent; leaves 5–9 parted pedately into linear lobes, 1–$2\frac{3}{4}$ in. long, petioles 2–6 in. long; flowers deep blue, $\frac{3}{4}$–1 in. broad. Ottawa and Auglaize Co.

21. **Viola emarginata** (Nutt) Le Conte. Triangle-leaf Violet. Leaves broadly ovate, deltoid-triangular, sharply dentate below the middle; flowers, violet blue. Cuyahoga and Lake Co.

22. **Viola fimbriatula** Smith. Ovate leaf Violet. Plant low, rather compact, pubescent; leaves ovate to oblong, $\frac{3}{4}$–$1\frac{1}{2}$ in. long, $\frac{1}{2}$–$\frac{5}{8}$ in. wide; petioles $\frac{1}{2}$–$1\frac{1}{2}$ in. long; flowers blue. Lake, Portage, Jefferson, Wayne, Licking Co.

23. **Viola sagittata** Ait. Arrow-leaf Violet. Plant rather low, glabrous; leaves deltoid-cordate, obscurely crenate, $\frac{3}{4}$–$2\frac{1}{2}$ in. long, $\frac{3}{8}$–$\frac{3}{4}$ in. wide; flowers violet blue, $\frac{3}{4}$ in. broad. Fulton, Wood, Erie, Lorain, Cuyahoga, Franklin, Lucas Co.

24. **Viola pedata** L. Bird's-foot Violet. Plant rather low, glabrous; leaves usually 9–lobed, cordate in outline, $\frac{1}{2}$–1 in. long, 1–$1\frac{1}{2}$ in. wide; flowers, large, blue or sometimes upper petals purple with dark purple at the center of the other lilac petals, stamens large conspicuous orange; petals not bearded. Lawrence County.

NOTES ON OHIO MOSSES.*

Clara Gould Mark.

Bryoziphium norvegicum (Bridel) Mitten. This moss was collected in Ohio as long ago as 1849 by Lesquereux, somewhere in the Lancaster region. In the 1863 edition of Gray's manual Sullivant says of it: "Fruit unknown. Pendent on the perpendicular faces of sandstone rocks, six miles south of Lancaster, Fairfield County, Ohio. The only other certain habitat recorded for this very interesting Moss is Iceland." As Sullivant himself was not a collector, he doubtless referred to the locality in which Lesquereux had collected the moss. Since that time this species has been collected in several other places in the United States, the only place where it has been found fruiting being the Dells of the Wisconsin, where at two different times a limited number of capsules was collected. The only specimen that has been in the State Herbarium was collected by Miss Riddle at Christmas Rocks in 1899. This moss is not uncommon on the vertical cliffs of the Black Hand sandstone in the Hocking Valley, and usually grows on the walls of the passages made by the enlarged joints in the sandstone, particularly where there are currents of cold air passing through these openings. The plants are usually small and sparsely scattered over the walls, often associated with other mosses. In one place, however, it has been recently found growing luxuriantly and the individual plants often reach a length of an inch and a half. It is rather interesting to note that this locality is six miles south of Lancaster. Perhaps it is the one referred to by Sullivant.

Buxbaumia aphylla Haller. A single specimen in the State Herbarium, collected in Lake County, in 1879, by Mr. H. C. Beardslee, is labeled "The first for Ohio." So far as there is any record here this is its only occurrence in the State previous to the fall of 1911. Sullivant gives its range as "New England and New York; rare," and Lesquereux and James give it "On the ground, especially of granite regions and mountains; White Mountains; Cascade Mountains, etc.," In the fall of 1911 three specimens were found along the side of a wood road near Jacob's Ladder, and in the spring and fall of 1912 numerous specimens were collected in the same locality. This new station for the species is nearly one hundred and fifty miles farther south than Beardslee's locality for it in Lake County. An interesting thing about this moss is the manner in which all the capsules point in the same direction—toward the strongest light.

* Read at the annual meeting of the Ohio Academy of Science, Columbus, Nov. 29, 1912.

Webera sessilis (Schmid.) Lindb. This moss had not been represented in the State Herbarium, but about a year ago it was found at Sugar Grove and since then has been found near Christmas Rocks. The capsules of this species, like those of Buxbaumia, point toward the source of the light supply. Sullivant gives its habitat as "Clayey or barren soil; not unfrequent in hilly districts", while Lesquereux and James give it as "Clayey and shady sandy banks along roads". The habitat of that in the Lancaster region seems to be somewhat unusual, as in the three places where the species was collected—in two ravines at Sugar Grove, and near Christmas Rocks—the plants were growing on the vertical faces of sandstone, in one instance being associated with *Bryoziphium norvegicum.*

Fig. 1. Buxbaumia aphylla.

Mnium punctatum (Hedw.). This species has not previously been recorded in the State Herbarium, but it seems to be fairly common in the Hocking Valley. Sullivant says that it occurs in "wet places, on the ground, Alleghany Mountains", and Lesquereux and James say "Cold springs and borders of brooks, on mountains, rarely fruiting." In the Sugar Grove region it is usually found near the heads of the ravines where the water runs or trickles over the rocks, and is often associated with liverworts. In the locality where the most luxuriant growth of *Bryoziphium norvegium* was found, *Mnium punctatum* is associated with it and grows on the vertical faces of the sandstone cliffs.

Polytrichum piliferum Schreb. This small Polytrichum is common in the Sugar Grove region and occurs on exposed ledges of the sandstone. It is often found in association with one or more of the other Polytrichums but grows in more exposed places than any of the others. It is a common thing to find *Polytrichum piliferum* growing in very thin dry soil on the most exposed ledges of sandstone, while a little farther back where the soil is slightly deeper *Polytrichum juniperinum* grows, and still farther back in more sheltered places, *Polytrichum commune* or *Polytrichum ohioense.* So far only sterile specimens have been collected,

but this species is easily distinguished from *Polytrichum juniperinum*, which it most nearly resembles, by its size and the long white awn-like tips to the leaves, which give the plant a hoary or grayish appearance.

LIST OF PLANTS COLLECTED IN CUYAHOGA COUNTY AND NEW TO THIS COUNTY OR TO OHIO.*

Edo Claassen.

These plants were collected in the course of this year and specimens of them will be sent to the Department of Botany, Ohio State University, to be added to its herbarium.

1. **Caryospora putaminum** (Schw.) DeNot. On old plum stones lying on the ground. Euclid.
2. **Diodia teres** Walton. On sandy hill. E. Cleveland.
3. **Erysiphe cichoracearum** DC. On Phlox paniculata L. (cult.), E. Cleveland.
4. **Erysiphe communis** (Wallr.), Fr. On Polygonum aviculare L., Euclid, on Ambrosia artemisiæfolia L., and on Baptisia tinctoria R. Br., E. Cleveland.
5. **Melampsora populina** Lev. On Populus grandidentata Michx. Olmsted Falls.
6. **Microsphæra alni** (DC.) Winter. On Sambucus canadensis L., and on Syringa vulgaris L. (cult.), E. Cleveland.
7. **Sphærotheca castagnei** Lev. On Nabalus altissimus (L.) Hook. E. Cleveland.
8. **Ustilago avenæ** (Pers.) Jensen. On Avena sativa L. Cleveland.

*Presented at the annual meeting of the Ohio Acad. of Sci., Columbus, Nov. 30, 1912.

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THE CHARACTERISTIC PLANTS OF A TYPICAL PRAIRIE.*

JOHN H. SCHAFFNER.

The characteristic plants of a typical prairie give to it an appearance immediately recognizable whether it is climatic or edaphic. If one had carefully prepared lists of the important plants of prairies in various part of the great Mississippi basin, it would be comparatively easy to select the plants of general distribution from those confined to special areas.

The prairie described below, not from an ecological but simply from a floristic standpoint, is situated in the center of the North American prairie province about one hundred miles east of the center of the transition zone to the plains region, in Clay County, Kansas. This region has never been glaciated and the surface rocks belong to the characteristic Dakota Sandstone.

The eastern limit of the transition zone is about forty miles to the west and may in this region be placed at the eastern limit of the range of the prairie dog (Cynomys ludovicianus) and the agricultural ant (Pogonomyrmex occidentalis), both of which are characteristic and abundant animals of the plains.

In the prairie under consideration there is, of course, some admixture of plains plants, but it is, nevertheless, a typical climatic prairie. The grasses which give color to the region are of the yellow-green type in summer and of a characteristic brown tint when dry, in winter. The color of the prevailing plains grasses is a grayish green, turning to grayish white in winter. These colors contrast sharply with the dark green of the pastures and meadows of Poas now largely developed in the eastern states.

*Contribution from the Botanical Laboratory, Ohio State University. No. 72.

The typical prairie grasses are the following four species, named in the order of their importance:

Andropogon furcatus Muhl. Big Blue-stem.
Andropogon scoparius Mx. Little Blue-stem.
Sorghastrum avenaceum (Mx.) Nash. Indian-grass.
Panicum virgatum L. Tall Smooth Panic-grass.

The Big Blue-stem may be regarded as *the* prairie grass. It grows in a close sod and formerly in certain years the flowering stems would be over ten feet high. On the richer uplands it grew with such luxuriance that the location of cattle and horses could frequently not be determined except by the waving of the tall stems as they passed through it. The Indian-grass usually occurs along with the big blue-stem, while the little blue-stem is characteristic of the higher drier slopes and hills. Along with the four large grasses mentioned above are the smaller gray-green grasses:

Atheropogon curtipendulus (Mx.) Fourn. Racemed Atheropogon.
Bouteloua oligostachya (Nutt.) Torr. Smooth Mesquite-grass.
Bouteloua hirsute Lag. Hairy Mesquite-grass.

In almost pure patches or mixed with the mesquite-grasses, is the very low-growing buffalo-grass, Bulbilis dactyloides (Nutt.) Raf., the most remarkable of the gray-green grasses of the plains. The patches of buffalo-grass are usually on the poorer clayey banks and slopes, a few yards to a number of rods in extent. The Texas spike-grass, Schedonnardus paniculatus (Nutt.) Trel., is frequently found on the buffalo-grass patches.

In the wet ravines and level, poorly drained second-bottom lands, Spartina cynosuroides (L.) Willd, tall slough-grass, forms large close patches, and in "gumbo spots" subject to moisture the salt marsh-grass, Distichlis spicata (L.) Greene, occurs.

On the ends of spurs or ridges between ravines where coyotes, burrowing owls, badgers, and other animals delight in making their burrows and thus cultivate the ground very thoroughly, the western couch-grass, Agropyron spicatum (Pursh) Scribn. & Sm., is often abundant. This grass was formerly the first to grow after the prairie had been burned off in the spring and was thus usually the first available green pasture for the pioneer's cattle.

There are several sedges on the upland and various species abound in moist ravines and about ponds. Many grasses besides those mentioned above also occur on the upland and in the ravines but those named are generally the characteristic species. The Republican River flows through this region with its wide flood-plain and there are here numerous species which do not extend to the upland. Such strips or ribbons of vegetation are, however, more or less edaphic and do not belong to the general floristic picture; just as the forest belts along the streams are not essentially different, except for the small number of species, from the vegeta-

tion on the young flood-plains of a forested region like Ohio. They owe their existence to the presence of the river and not to the climatic conditions.

The prairie fire, although not the cause of the prairies, had, nevertheless, a profound effect on their vegetation. When the fires swept over the prairie in the spring, it burned up everything down to the ground, and perennial herbs and shrubs had each year to meet anew the competition above ground of the all-conquering grasses. Frequently the fires occurred in the fall and thus the soil was exposed, without covering, during the entire winter to dryness, wind and cold. Since the fires have ceased even the patches of prairie still remaining are undergoing a rapid and remarkable change in vegetation. The change in the relative abundance of certain species is no less interesting than the arrival of new forms from other regions.

After the characteristic grasses, the most prominent members of the prairie vegetation are a number of shrubs and perennial geophilous herbs. The latter are usually crownformers, often with exceedingly long taproots. When one sees such plants exposed in the banks of a stream or an arroyo, one realizes what a large part of the vegetation is underground in summer as well as in winter.

The woody or semi-woody species are few in number, though several are among the characteristic prairie plants. The most important one in the region under consideration is the shoe-string, Amorpha canescens Pursh, which is a low shrub a foot or two in height. Others are, Rosa arkansana Port., Arkansas Rose, Meriolix serrulata (Nutt.) Walp., Tooth-leaf Evening-primrose, and Morongia uncinata (Willd.) Britt., Sensitive-brier. The latter is only slightly woody. In the ravines, Amorpha fruticosa L., false indigo, is especially abundant on the banks of ponds. Salix fluviatilis Nutt., Sandbar willow, grows in small dense thickets in moist ravines and is occasionally present on banks and hillsides. In such situations, however, the shrub is always very small.

Very few seedless plants thrive on a typical prairie. There are no ferns on the prairie proper but Woodsia obtusa (Spreng.) Torr. grows on moist sandstone cliffs along with several species of mosses, liverworts, and lichens. Equisetum kansanum Schaff. occurs on clayey banks and slopes and Marsilea vestita H. & G. grows occasionally in buffalo-wallows in low places. The Marsilea seems to be near its eastern limit and is properly a plant of the plains. There are very few mosses but some small ground-loving lichens occur especially on the hills and Nostoc commune Vauch. is abundant on the banks of ravines. The giant puffball, Lycoperdon giganteum Batsch., often occurs in large numbers and in suitable seasons various other species of puffballs, toadstools and stink-horns make their appearance.

There is one prickly-pear, Opuntia sp., with fragrant flowers and edible fruit which ripens in late autumn. It is quite common especially in patches of buffalo-grass or in gumbo patches where it does not have to meet the competition of the Andropogons. On the very highest hills Cactus missouriensis (Sweet.) Ktz., the Missouri cactus, grows although it is quite rare.

Besides the grasses, the most characteristic plants of the prairie, as stated above are perennial geophytes, mostly crown-formers with deep taproots. Of special prominence are Psoralea floribunda Nutt., many-flowered Psoralea, and Psoralea argophylla Pursh, silver-leaf Psoralea. Both species are tumbleweeds, being separated from the perennial base by means of cleavage planes developed in the stems near the ground. Psoralea esculenta Pursh, prairie-apple, with its thickened root is also common. In the spring and early summer, three species of wild-indigo are found here and there as conspicuous members of the flora, namely, Baptisia australis (L.) R. Br., Baptisia bracteata Ell., and Baptisia leucantha T. & G. having blue, cream-colored, and white flowers respectively.

Other large and conspicuous species are as follows:

Verbena stricta Vent. Hoary Vervain.
Verbena hastata L. Blue Vervain.
Vernonia baldwini Torr. Baldwin's Ironweed.
Euphorbia marginata Pursh. Snow-on-the-mountain.
Carduus undulatus Nutt. Wavy-leaf Thistle.
Artemisia gnaphalodes Nutt. Prairie Mugwort.
Artemisia ludoviciana Nutt. Lobed Mugwort.
Glycyrrhiza lepidota Pursh. Wild Liquorice.
Helianthus maximiliani Schrad. Maximilian's Sunflower.
Helianthus subrhomboideus Rydb. Rhombic-leaf Sunflower.
Heliopsis scabra Dun. Rough Oxeye.
Lespedeza capitata Mx. Round-headed Bush-clover.
Allionia linearis Pursh. Narrow-leaf Umbrella-wort.
Ambrosia psilostachya DC. Western Ragweed.
Acuan illinoensis (Mx.) Ktz. Illinois Acuan.
Salvia pitcheri Torr. Pitcher's Sage.
Meibomia—several species.
Lactuca—several species.
Hieracium longipilum Torr. Long-bearded Hawkweed.
Nabalus asper (Mx.) T. & G. Rough Rattlesnake-root.
Onagra biennis (L.) Scop. Common Evening-primrose.
Gaura parviflora Dougl. Small-flowered Gaura.
Gaura biennis L. Biennial Gaura.
Onosmodium carolinianum (Lam.) DC. Slaggy False-gromwell.
Grindelia squarrosa (Pursh) Dun. Broadleaf Gum-plant.
Cuscuta paradoxa Raf. Glomerata Dodder, a conspicuous parasite mostly on the tall herbs of the sunflower family, growing in ravines but occasionally on the upland.

Among the smaller plants usually common may be mentioned:

Juncus tenuis Willd. Slender Rush.
Panicum—several small species.
Antennaria campestris Rydb. Prairie Everlasting.
Plantago purshii R. & S. Pursh's Plantain.
Achillea lanulosa Nutt. Western Milfoil.
Astragalus—several species.
Oxalis violacea L. Violet Wood-sorrel.
Linum sulcatum Ridd. Grooved Yellow Flax.
Kuhnia glutinosa Ell. Prairie Kuhnia.
Erigeron ramosus (Walt.) B. S. P. Daisy Fleabane.
Mesadenia tuberosa (Nutt.) Britt. Tuberous Indian-plantain.
Kuhnistera purpurea (Vent.) MacM. Violet Prairie-clover.
Kuhnistera candida (Willd.) Ktz. White Prairie-clover.
Physalis virginiana Mill. Virginia Groundcherry.
Asclepiodora viridis (Walt.) Gr. Oblong-leaf Milkweed.

Among the early spring flowers that grow on the upland, and not mentioned above, the following are notable:

Anemone caroliniana Walt. Daisy Anemony.
Anemone decapetala Ard.—— This is not distinct from the preceding. There are a number of elementary species. The colors are white blue and reddish pink, the blues being of many shades.
Nothocalais cuspidata (Pursh) Greene. Wild-dandelion.
Viola pedatifida Don. Prairie Violet.
Sisyrinchium campestre Bickn. Prairie Blue-eyed-grass.
Lithospermum linearifolium Goldie. Narrow-leaf Puccoon.
Callirrhoe alceoides (Mx.) Gr. Light Poppy-mallow.
Callirrhoe involucrata (T. & G.) Gr. Purple Poppy-mallow—mostly in ravines and bottoms.
Vicia linearis (Nutt.) Greene. Narrow-leaf American Vetch.
Tradescantia, sp.

The above would represent the usual plants in a prairie boquet gathered in the spring, although a few additions might be made to it from the ravines.

The summer and autumn flowers include among others the following:

Solidago—several species, the most beautiful being the early-blooming S. missouriensis Nutt., Missouri Goldenrod.
Aster—several species including the beautiful silky aster, A. sericeus Vent.
Ruellia ciliosa Pursh. Hairy Ruellia.
Ratibida columnaris (Sims) D. Don., Long-headed Prairie-cone-flower.
Lacinaria punctata (Hook.) Ktz. Dotted Blazing-star.
Gyrostachys, two species.
Gerardia tenuifolia Vahl. Slender Gerardia.
Gentiana—a beautiful undetermined species with deep blue flowers.

This prairie is changing rapidly through the influences brought in by the settlement of the country and because of extensive cultivation and pasturing. Even now it would be difficult for one who has never seen the original, endless sweep of green vegetation as it extended over hill and plain, before the advent of the early settlers who came in great numbers in 1869–71, to form a clear conception of the prairie's former grandeur or to realize the important floristic changes that have already taken place and that are still in progress.

THE CLASSIFICATION OF PLANTS, VIII.

John H. Schaffner.

Below is presented a synopsis of the fifteen plant phyla given in the preceding paper of this series. The classification of the fungi follows with a key to the orders.

The following changes should be made in the arrangement of the families of Anthophyta as presented in the sixth paper: Transfer the Parnassiaceae from Saxifragales to Ranales following the Ranunculaceae. Interchange the position of Loganiaceae and Oleaceae. Also interchange the position of Bromeliaceae and Dioscoreaceae.

SYNOPSIS OF THE PLANT PHYLA.

A. Plant body unicellular or filamentous, or if a solid aggregate through the ovary, when present, not an archegonium; never seed-producing; nonsexual, with a simple sexual life cycle, or with an alternation of generations.

I. Cells typically with poorly differentiated nuclei and chromatophores, reproducing by fission; motile or nonmotile, colored or colorless, with or without chlorophyll but never with a pure chlorophyll-green color; resting spores commonly present.
Phylum 1. Schizophyta.

II. Cells with well differentiated nuclei, and if holophytic usually with definite chromatophores; with or without chlorophyll; colorless, green, or variously tinted by coloring matters.

(I.) Nonsexual, unicellular plants without chlorophyll having a plasmodium stage of more or less completely fused amoeboid cells from which complex sporangium-like resting bodies are built up. Phylum 2. Myxophyta.

(II.) Plants not developing a plasmodium, but the cells normally covered with walls in the vegetative phase.

1. Unicellular or filamentous plants containing chlorophyll, either brown with silicious, two-valved walls or green with complex chromatophores, the walls not silicified; conjugating cells not ciliated, isogamous.
Phylum 3. Zygophyta.

2. Plants not with silicified, two-valved walls, if with a direct conjugation of nonmotile cells or branches then without chlorophyll.

(1.) Plants with chlorophyll; if without chlorophyll then either without a true mycelium, or if a mycelium is present having a sexual phase with ciliated, motile sperms.

a. Antheridium when present not consisting of a globular structure containing sperm-bearing filaments; often with an alternation of generations.

(a.) Plants green with chlorophyll or colorless, nearly all producing nonsexual zoospores, the sexual forms isogamous or heterogemous.
Phylum 4. Gonidiophyta.

(b.) Plants with chlorophyll hidden by a brown, red, or purple pigment, always with a multicellular body and with sexuality.

((a.)) Mostly marine brown algae with phycophaein; isogamous or heterogamous, with ciliated sperms, both gametes discharged from the gametangia. Phylum 5. PHAEOPHYTA.

((b.)) Mostly marine red algae with phycoerythrin; heterogamous, with stationary eggs and non-ciliated sperms. Phylum 6. RHODOPHYTA

b. Filamentous, aquatic, green algae with globular antheridia containing sperm-bearing filaments, the sperms being biciliated; nonsexual spores absent. Phylum 7. CHAROPHYTA.

(2.) Plants without chlorophyll and with a true mycelium; sexual reproduction if present without motile sperms; sometimes with an alternation of generations. Phylum 8. MYCOPHYTA.

B. Plant body a solid aggregate, if filamentous, only so in the embryonic condition; ovary an archegonium, if a reduced archegonium then the plants seed-bearing; always with an antithetic alternation of generations in the normal life cycle.

I. Without vascular tissue; sphorophyte parasitic on the gametophyte during its entire life; homosprous; small plants without roots or true leaves. Phylum 9. BRYOPHYTA.

II. Always with vascular tissue in the sporophyte which becomes an independent plant at maturity, with roots and leaves except in a few degenerate forms.

1. Sporophyte not seed-producing, the sperms breaking out of the antherifdum to enter the necks of the archegonia; homosporous or heterosporous.

a. Sperms comparatively large, multiciliate; the sporophylls not in cones unless the sporophytes have jointed stems and small whorled leaves.

(a.) Stems not jointed, the leaves usually large and compound and spirally arranged, rarely in whorles; sporophylls never in cones. Phylum 10. PTENOPHYTA.

(b.) Stems jointed and fluted, bearing small, whorled leaves; sporophylls in cones. Phylum 11. CALAMOPHYTA.

b. Sperms small, biciliate; the leaves small and simple, covering the continuous stem in spirals or sometimes opposite; sporophylls usually in cones or sometimes forming zones alternating with the sterile leaves. Phylum 12. LEPIDOPHYTA.

2. Sporophyte producing seeds, the female gametophyte always parasitic in the megasporangium (ovule) during its entire life, the male gametophyte developing a pollen-tube through which the sperms are discharged; always heterosporous.

a. Carpels (megasporophylls) open, without stigmas or true ovularies, the ovules and seeds naked and the pollen (male gametophytes) falling directly into the micropyle.

(a.) Sperms so far as known ciliated and motile; ovules with a pollen-chamber; sporophylls in spiral rosettes or aggregated into cones. Phylum 13. CYCADOPHYTA.

(b.) Sperms without cilia, ovules without definite pollen-chambers; sporophylls in cones which may be highly specialized, or reduced. Phylum 14. STROBILOPHYTA.

b. Carpels or the set of carpels (megasporophylls) closed at maturity, with stigmas and with ovularies enclosing the ovules and seeds; pollen (male gametophytes) falling on the stigma and developing long pollentubes; flowers well developed, usually with a perianth, often highly specialized or reduced. Phylum 15. ANTHOPHYTA.

The following arrangement of the fungi is the result of several years of study in attempting to discover the natural relationships of the thallophytes without chlorophyll. It is no doubt far from what must be the final arrangement, yet it is believed to represent the phyletic classification so far as present investigation has indicated lines of sequence and homologies. Where there has been no decided evidence to the contrary, the system and terminology have not been changed from that which is in rather general use.

In classifying fungi, as well as other groups, the supposed relationships cannot be determined by taking a single character or set of characters into consideration but every part and function in the entire life cycle must be duly considered. Many essentially similar structures and processes have developed entirely independently of one another. In recent years, it seems that various attempts have been made to read the ordinary antithetic life cycle into the higher fungi. It is probable that alternation of generations had several independent origins even in the unicellular forms, and the original cycle may have been modified in various ways. One thing is clearly evident, that it is possible to have an alternation of sexual and nonsexual phases with both generations having either the haploid or diploid number of chromosomes.

The lichens have not been distributed farther than the subclasses, perhaps not as far as present day knowledge would warrant but we need much more morphological and cytological investigation of both the ordinary Ascomycetae and the Ascolichenes before a fairly certain arrangement is possible.

Whether the Mycophyta, as delimited by the writer, represent two main origins and two phyla or whether the Phycomycetae should be joined with the Gonidiophyta are still open questions, but there is at least a very serious array of objections against the hypothesis that the typical Ascomycetae and the Laboulbenieae have had their origin from the red algae rather than from the more primitive Gonidiophyta. The marine nature of the red algae, with their lack of semiparasitic aerial forms, as well as the

very great difference in the type of alternation of generations point to the conclusion that the evident similarities between the two groups are rather to be regarded as analogous developments. Unless the case can be made much more evident than at present, even the more or less superficial similarity between the structures of the ascocarp and cystocarp cannot be urged as very strong evidence in favor of a direct origin from the Rhodophyta.

Whether all the fungi containing an ascus should be placed in a single class and whether the Teliosporeae should be retained in a class distinct from the Basidiomycetae are questions which depend on one's definition or conception of a class. It is very desirable to have a system that is fairly consistent for the entire plant kingdom, if botany is to be a science and not simply a group of disjointed subjects.

FUNGI.

I. SCHIZOPHYTA. Fission Plants.
- 1. **Schizomycetae.** Fission Fungi.
  - a. Bacteriales. Bacteria.
  - b. Desmobacteriales. Filamentous Bacteria.
  - c. Rhodobacteriales. Purple Bacteria.
- 2. **Myxoschizomycetae.** Slime Bacteria.
  - a. Myxobacteriales.

II. MYXOPHYTA. Slime Molds.
- 1. **Plasmodiophoreae** (?) [Parasites.]
  - a. Plasmodiophorales.
- 2. **Myxomycetae** [Saprophytes.]
  - (1.) *Acrasieae.*
    - a. Acrasiales.
  - (2.) *Myxogastreae.*
    - a. Ceratiomyxales.
    - b. Myxogastrales.

IV. GONIDIOPHYTA. Zoospore Plants.
- 1. **Archemycetae.** Primitive Fungi.
  - a. Chytridiales.
- 2. **Monoblepharideae.** [With normal gametes.]
  - a. Monoblepharidales.

VIII. MYCOPHYTA. Typical Fungi.
- A. PHYCOMYCETAE. Algal Fungi.
  - 1. **Zygomycetae.**
    - a. Mucorales. Black Molds.
    - b. Entomophthorales. Insect-cholera Fungi.
  - 2. **Oomycetae.**
    - a. Ancylistales.
    - b. Saprolegniales. Water Molds.
    - c. Peronosporales. Common Mildews.
- B. MYCOMYCETAE. Higher Fungi.
  - 3. **Ascomycetae.** Sack Fungi.
    - (1.) *Hemiasceae.* Intermediate Sack Fungi.
      - a. Ascoideales.
    - (2.) *Aspergilleae.* Tuber Fungi.
      - a. Aspergillales. Little Tuber Fungi.
      - b. Tuberales. Truffles.

(3.) *Discomycetae.*
  a. Hysteriales. Slit Fungi.
  b. Phacidiales. Little Cup Fungi.
  c. Pezizales. Cup Fungi.
  d. Protocalieiales.
  e. Helvellales.
(4.) *Discolichenes.*
  a. Coniocarpales.
  b. Graphidales.
  c. Cyclocarpales.
(5.) *Pyrenomycetae.*
  a. Hypocreales.
  b. Dothideales.
  c. Sphaeriales.
  d. Perisporiales. Powdery Mildews.
(6.) *Pyrenolichenes.*
  a. Pyrenulales.
  b. Mycoporales.
(7.) *Exoasceae.*
  a. Exoascales.
  b. Saccharomycetales. Yeast-plants.
(8.) *Deuteromycetae.* Imperfect Fungi.
  a. Moniliales. Common Molds.
  b. Melanconiales. Black-dot Fungi.
  c. Sphaeropsidales. Spot Fungi.

4. **Laboulbenieae.** Beetle Fungi.
  a. Laboulbeniales.

5. **Teliosporeae.** Brand Fungi.
  a. Tilletiales. Stinking Smuts.
  b. Ustilaginales. Loose Smuts.
  c. Uredinales. Plant Rusts.

6. **Basidiomycetae.** Basidium Fungi.
(1.) *Protobasidiae.*
  a. Auriculariales. Ear Fungi.
  b. Tremellales. Jelly Fungi.
  c. Dacryomycetales.
(2.) *Hymenomycetae.*
  a. Agaricales.
(3.) *Hymenolichenes.*
  a. Corales.
(4.) *Gastromycetae.*
  a. Hymenogastrales. False Truffles.
  b. Sclerodermatales. Thick-skinned Puffballs.
  c. Lycoperdales. Puffballs.
  d. Nidulariales. Bird-nest Fungi.
  e. Phallales. Stink-horns.

Key to the Orders of Fungi.

The Fungi are Thallophytes without chlorophyll but sometimes inclose chlorophyll-containing Algae in the meshes of their bodies.

1. Plant body not a true mycelium, usually unicellular, or the cells sometimes in simple or branched filaments; some forms with a plasmodium, others with a sack-like body containing cells; the resting or spore stage sometimes consisting of a sporangium-like body without cell structure, with enclosed spores. 2.

1. Plant body a more or less perfectly developed mycelium consisting of septate or nonseptate hyphae. 7.

2\. Plants consisting of minute, distinct cells with walls, or with the cells arranged in simple or branched filaments; the cells sometimes in a gelatinous mass; often ciliate; nuclei poorly differentiated.
SCHIZOMYCETAE. 3.

2\. Plant body of minute distinct cells in a pseudoplasmodium, the whole mass motile; fruiting bodies of definite form somewhat like the sporangia of slime molds; saprophytes.
MYXOSCHIZOMYCETAE. **Myxobacteriales.**

2\. Plant body of oval or elongated, comparatively large, nonmotile cells which increase by budding; commonly present in sugary solutions and fruit juices causing alcoholic fermentation. **Saccharomycetales.**

2\. Plant body when mature consisting of cells in a sack-like structure; usually parasitic in the cells of algae, pollengrains in water, and occasionally in the cells and tissues of higher plants.
ARCHEMYCETAE. **Chytridiales.**

2\. Plant body a motile plasmodium of naked cells, the fruiting stage usually a so-called sporangium, usually without cell structure excepting the spores within; saprophytic, rarely parasitic.
MYXOMYCETAE. 4.

3\. Cells spherical, rod-shaped, curved, or spiral, free or in simple or loose aggregates or filaments, motile or nonmotile, some with cilia or flagella; not with a purple pigment in the protoplasm. **Bacteriales.**

3\. Cells spherical, rod-shaped, or spiral, containing a purple pigment called bacterio-purpurin. **Rhodobacteriales.**

3\. Cells in filaments surrounded by a sheath, or filaments without a sheath but with active movement by means of an undulating cell membrane. **Desmobacteriales.**

4\. Parasitic in the cells of living plants, the cells forming a plasmodium; the fructification consisting of a mass of free cells.
Plasmodiophorales.

4\. Saprophytes developed on decaying organic matter. 5.

5\. Amoeboid cells massed together in an imperfect plasmodium; ripe fructification consisting of masses of free cells, sometimes on a stalk. **Acrasiales.**

5\. Vegetative body a true plasmodium; with free, white stalked spores or with spores in a sporangium-like receptacle. 6.

6\. With free, white, stalked spores. **Ceratiomyxales.**

6\. With spores in sporangium-like receptacles. **Myxogastrales.**

7\. Mycelium nonseptate, or if septate still with coenocytic divisions; spores not in asci nor on basidia, usually formed as the result of the conjugation of two similar or dissimilar hyphal branches; zoospores or conida present in most forms and in some cases nonmotile, nonsexual spores in special sporangia. 8.

7\. Mycelium definitely septate; spores in the normal forms borne in asci or on basidia, in some groups the basidia developing from chlamidospores; numerous imperfect forms with only the conidial stage known. 11.

8\. Mycelium with septa; reproduction by means of true eggs and free-swimming spermatozoids; aquatic molds.
MONOBLEPHARIDEAE. **Monoblepharidales.**

8\. Sexual spores produced by the conjugation of two equal or nearly similar hyphal branches; mycelium saprophytic or parasitic on plants and animals, especially on insects; no zoospores produced.
ZYGOMYCETAE. 9.

8\. Sexual spores produced by the conjugation of a large branch and a small branch, the smaller penetrating the larger by means of a tubular process; mycelium parasitic or saprophytic; aquatic molds on living or dead animals or aerial plant parasites, often with nonsexual zoospores. OOMYCETAE. 10.

9. Saprophytic, or occasionally parasitic on other molds. **Mucorales.**
9. Parasitic on insects, as flies, grasshoppers, plant lice, etc. **Entomophthorales.**
10. Mycelium poorly developed, with septa; endophytic parasites, mostly in fresh water algae, some in the roots of higher plants. **Ancylistales.**
10. Saprophytic or parasitic, mostly aquatic molds; mycelium well developed; nonsexual reproduction by zoospores. **Saprolegniales.**
10. Parasitic on the higher plants; nonsexual reproduction by aerial conidia which may give rise to zoospores. **Peronosporales.**

—11—

11. Hyphae usually forming sporocarps having spores enclosed in asci. Ascomycetae. 12.
11. Plant body minute, erect, few-celled, growing parasitic on insects; perithecia on a receptacle; asci usually 4-spored. Laboulbenieae. **Laboulbeniales.**
11. Parasites with basidia coming from chlamidospores (teleutospores) which are with or without stalks. Teliosporeae. 31.
11. Hyphae usually forming sporocarps bearing basidiospores on basidia arising directly from the mycelium. Basidiomycetae. 33.
11. Hyphae bearing only conidia, in pycnidia, or the conidia superficial borne on loose or innate hyphae; asci or basidia not known. Deuteromycetae. 29.
12. Fungi symbiotic with algal cells. Ascolichenes. 13.
12. Fungi without helotic algae in their bodies. 17.
13. Asci on an apothecium. Discolichenes. 14.
13. Asci in a perithecium. Pyrenolichenes. 16.
14. Paraphyses forming a powdery mass with the spores, the paraphyses growing beyond the asci, forming there a network, adhering to the disk of the apothecium which soon breaks up into a powdery mass with the spores. Algae belonging to the Gonidiophyta. **Conyocarpales.**
14. Paraphyses not forming a powdery mass with the spores. 15.
15. Disk of the apothecium linear, ellipsoid, or somewhat angular. Algae belonging to the Gonidiophyta. **Graphidales.**
15. Disk of the apothecium circular. Algae belonging to the Gonidiophyta or to the Cyanophyceae. **Cyclocarpales.**
16. Cavity of the perithecium simple, not divided by complete or incomplete partitions. **Pyrenulales.**
16. Cavity of the perithecium divided by complete or incomplete partitions. **Mycoporales.**
17. Asci with a variable number of spores, usually many-spored. Hemiasceae. **Ascoideales.**
17. Asci with a definite number of spores in typical cases, separate from each other, not forming a definite fruiting body. Exoasceae. 18.
17. Asci with a definite number of spores in typical cases, collected on or in an ascocarp. 19.
18. Asci approximate and forming an indefinite hymenium; mostly parasitic **Exoascales.**
18. Asci entirely isolated; vegetative reproduction by budding of the cells; plants producing alcoholic fermentation. **Saccharomycetales.**
19. Asci collected in enclosed tuber-like bodies or fasciculate, and surrounded by a spherical, cylindric, pyriform or shield-like wall, the perithecium. 24.
19. Asci collected in a flattened, concave or convex hymenial layer (Ascoma). Discomycetae. 20.
20. Apothecia pulverulent, spheroidal, plants saprophytic. **Protocaliciales.**
20. Apothecia not pulverulent. 21.

21. Ascoma more or less completely closed at first, opening free at or before maturity, and plane, concave, or rarely convex. 22.
21. Ascoma open from the first, normally convex and commonly with the surface pitted or with gyrose furrows. **Helvellales.**
22. Ascoma long enclosed in a tough covering which is torn open at the maturity of the spores. 23.
22. Ascoma soon becoming free, without special covering; mostly fleshy cuplike fungi. **Pezizales.**
23. Ascoma mostly elongate, the cones opening by a longitudinal fissure. **Hysteriales.**
23. Ascoma roundish, the cover rupturing by radiating or stellate fissures. **Phacidiales.**
24. Asci arranged at different levels in the perithecium or in a hymenium lining enclosed cavities. ASPERGILLEAE. 25.
24. Asci in fascicles arising from a common level. 26.
25. Asci arranged at different levels, sometimes forming skein-like masses. **Aspergillales.**
25. Asci in a definite flat hymenium lining cavities, permanently enclosed; fruiting body mostly subterranean. **Tuberales.**
26. Cleistotheeia globose, scattered, without apparent ostiole, usually with appendages, mostly attached to an apparent mycelium or membrane; in one family flat shield-shaped perithecia with ostiole present. **Perisporiales.**
26. Perithecia typical with distinct ostiole. 27.
27. Perithecia (and stroma if present) fleshy or membranous, bright-colored (white, red or blue). **Hypocreales.**
27. Perithecia (and stroma if present) hardened, never fleshy, rarely membranous, dark-colored (black or dark brown). 28.
28. Walls of the perithecia scarcely distinguishable from the stroma. **Dothideales.**
28. Perithecia with distinct walls either free or imbedded in a stroma. **Sphaeriales.**
29. Conidia borne on short stalks in pycnidia. **Sphaeropsidales.**
29. Conidia superficial, borne on loose or innate hyphae; no true pycnidia present. 30.
30. Hyphae somewhat superficial, often floccose. **Moniliales.**
30. Hyphae innate with the matrix; parasitic; the conidia borne on a pseudo-pycnidium, formed from the altered tissue of the host. **Melanconiales.**

—31—

31. Chlamydospores produced in the ovularies, leaves or stems of the host, usually black, not stalked. 32.
31. Chlamydospores (teleutospores) usually stalked, producing black or brown pustules under the epidermis of leaves or stems; often developing on the same or on a different host clusters of cup-like or crater-like aecidia with spores formed in chains inside of a membranous pseudoperidium. **Uredinales.**
32. Chlamydospores developing a several-celled basidium (promycelium) which bears the spores at the sides of the cells. **Ustilaginales.**
32. Chlamydospores developing a nonseptate basidium which bears the spores at the apex. **Tilletiales.**
33. Fungi symbiotic with algal cells. HYMENOLICHENES. **Corales.**
33. Fungi without helotic algae in their bodies. 34.
34. Plants gelatinous, basidia divided, transversely or longitudinally or deeply two-forked. PROTOBASIDIAE. 35.
34. Plants fleshy, coriaceous, woody, or rarely somewhat gelatinous; basidia nonseptate. 36.
35. Basidia transversely septate. **Auriculariales.**

35. Basidia divided obliquely or lengthwise, commonly into four parts. **Tremellales.**
35. Basidia deeply two-forked, not completely divided. **Dacryomycetales.**
36. Basidia on a distinct membranous hymenium, naked at maturity and covering gills, pores, spines, or a smooth or wrinkled surface. HYMENOMYCETAE. **Agaricales.**
36. Basidia enclosed within a definite peridium but sometimes exposed at maturity, the spores then borne in a more or less deliquescent gleba. GASTROMYCEAE. 37.
37. Spores borne in a more or less deliquescent gleba which is at first enclosed in an egg-like body but at maturity elevated on an elastically expanding stalk or base. **Phallales.**
37. Spores remaining within the peridium or in the hymenial cavities until maturity. 38.
38. Basidia united into a hymenium which lines the walls of irregular cavities. 39.
38. Basidia uniformly distributed through the peridium or forming skein-like masses. **Sclerodermatales.**
39. Hymenial cavities remaining together within the peridium, their boundaries mostly disappearing at maturity. 40.
39. Hymenial cavities (sporangioles) separating at maturity from the cup-like peridium. **Nidulariales.**
40. Remaining fleshy until the maturity of the spores; no capillitium. **Hymenogastrales.**
40. Fleshy when young, at maturity filled with dust-like spore masses mixed with the capillitium. **Lycoperdales.**

ADDITIONS MADE TO THE CEDAR POINT FLORA DURING THE SUMMER OF 1912.

E. L. FULLMER.

Setaria italica (L) Beauv. July 14, L. H. Pammel.
Hordeum vulgare L. July 14, L. H. Pammel.
Fagopyrum esculentum Moench. July 4, E. L. Fullmer.
Chelidonium majus L. June 28, L. H. Pammel.
Melilotus officinalis (L.) Lam. July 13, E. L. Fullmer.
Verbascum blattaria L. July 4, E. L. Fullmer.
Galinsoga parviflora Cav. July 19, L. H. Pammel.

These plants with the exception of Chelidonium majus were collected at or near the resort and were probably introduced in grass seed or in packing material. A single plant of Chelidonium majus was found on the bay side about one half mile from the resort. The seed from which this plant grew may have been carried by a bird or it may have been carried across the Bay on drift material.

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*Presented at the annual meeting of the Ohio Acad. of Sci., Columbus, November 29, 1912.

THE OHIO DOGBANES.

LILLIAN E. HUMPHREY.

APOCYNACEAE. Dogbane Family.

Perennial erect or trailing herbs, shrubs, or vines; usually with milky acrid sap. Leaves simple, more commonly opposite, without stipules; flowers hypogenous, sympetalous, tetracyclic, with actinomorphic perianth; andreecium pentamerous, the stamens distinct, united with the corolla at least at the base; pollen not in masses; gynecium of two united carpels, but the ovularies separating below the style; fruit usually two follicles; seeds often appendaged with a tuft of long hairs.

Key to the Genera.

1. Flowers solitary, large, axillary; trailing herbs. *Vinca.*
1. Flowers cymose; erect herbs. *Apocynum.*

Vinca L. Periwinkle.

Perennial trailing herbs with opposite, evergreen leaves, and large, solitary, axillary flowers. Stem slightly woody; calyx segments acuminate; corolla salverformed, blue; stamens included; disk of 2 glands alternate with the two carpels; follicles with several ovules and seeds; seeds oblong-cylindric, without hairs.

Vinca minor L. Periwinkle. Leaves glabrous oblong to ovate, entire, firm, shining, green on both sides, narrowed at the base, short petioled. Escaped from cemeteries and gardens. Huron, Montgomery, Vinton, Portage, Williams, Stark, Wayne, Coshocton, Richland, Auglaize, Lawrence.

Apocynum L. Dogbane.

Perennial erect herbs with opposite, entire, leaves and white or pink flowers in corymbed cymes. Corolla usually campanulate, having five small triangular appendages within alternating with the stamens; follicles slender; long, terete, containing numerous ovules with tufts of long hairs.

Key to the Species.

1. Corolla much longer than the ovate pointed divisions of the calyx; branches diverging; flowers 1/4 to 1/2 inch long. 2.
1. Corolla not longer than the lanceolate divisions of the calyx; branches upright, ascending; terminal cyme not extending above the lateral branches; flowers small. 3-16 to 1/4 inch long. 3.
2. Corolla campanulate, recurved, not angled, pinkish, narrowed in the throat. *A. androsaemifolium.*
2. Corolla urceolate, five-angled, white or only slightly tinged with pink, spreading. *A. urceolifer.*
3. Leaves petioled. 4.
3. Leaves not petioled, lower ones more or less clasping, the upper ones sessile. *A. hypericifolium.*

4. Leaves and cymes smooth or very slightly pubescent. 5.
4. Leaves and cymes very densely pubescent. *A. pubescens.*
5. Leaves lanceolate to obovate, 2 to 4 times as long as wide; terminal cyme larger than the axillary; flowers greenish. *A. cannabinum.*
5. Leaves rather small lanceolate 4 to 6 times as long as wide; flowers white. *A. album.*

1. **Apocynum androsaemifolium** L. Spreading Dogbane. Dichotomously branched stems 1 to 5 feet high; root stalk horizontal, leaves ovate to obovate, usually twice as long as wide, glabrous and dark green above, more or less pubescent and light green beneath, short petioled with mucronate apex, and a broad base; cymes both terminal and axillary with short pediciled, campanulate, pink, sympetalous flowers with reflexed corolla segments. Common in fields and thickets. General.

2. **Apocynum urceolifer** Mill. Urnflowered Dogbane. Slender stems about 3 feet high with widely spreading branches; cymes small with white or slightly pink tinged flowers and spreading, pointed corolla segments; calyx segments lanceolate; leaves oblong, mucronate, slightly pubescent beneath. Along roadsides and fields. Auglaize County.

3. **Apocynum cannabinum** L. Indian Hemp. Stems 3 to 5 feet high with erect or ascending branches and long verticle roots; leaves lanceolate to oblanceolate, apex mucronate, base of upper ones acute while the lower ones are often rounded, short petioled, 4 to 5 inches long, ¾ to 1½ inches wide, glabrous above, sometimes pubescent beneath, cymes dense, short pediceled, with bracts at the base and greenish white flowers. Common in fields and waste places. General.

4. **Apocynum album** Greene. River-bank Dogbane. Glabrous stems with lanceolate, smooth, petioled, acute leaves 4 to 6 times as long as wide; cymes dense with small white flowers. River banks and moist fields. Coshocton, Lake, Butler, Mercer, Montgomery, Clermont, Holmes.

5. **Apocynum hypericifolium** Ait. Clasping-leaf Dogbane. Stems glabrous often glaucous, 1 to 2 feet high with ascending branches, leaves oblong to oblanceolate, upper ones very short petioled or sessile, lower ones clasping; cymes dense, bracted, with pedicles about as long as the flowers; calyx segments lanceolate acute. In dry soil, especially in sandy places. Erie, Ashtabula.

6. **Apocynum pubescens** R. Br. Velvet Dogbane. Entire plant densely velvety pubescent; ascending branches with ovate to oblong, mucronate leaves often twice as long as wide and obtuse at the base; venation strongly impressed in the velvety under surface; calyx segments lanceolate, acute; corolla purple, lobes erect. In waste places and flood planes near streams. Franklin, Auglaize, Harrison, Adams.

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LIFE-HISTORIES OF SYRPHIDAE V.

C. L. METCALF.

Syrphus xanthostoma Williston.
The Pemphagus-Gall Syrphus-Fly.

(Plate IV, Figs. 81 to 89).

Larva.

Length about 10 mm. (8 to 11.5), width 3.75 to 4 mm., height 2.5 to 3 mm. Fat, thick, grub-like, sluggish larvæ, elongate oviform in outline, strongly arched dorsally (Fig. 82). Wrinkles prominent, produced laterally into an irregular, dorso-lateral carina; the ventral folds of the body in the principal segments serve as very imperfect prolegs. General color very pale, pinkish-yellow. Heart line not conspicuous. Skin bare, the segmental bristles short and light in color, very inconspicuous.

The jaws of the mouth-parts are unusually short, their width at base equal to their length, the lower jaw the heavier. Mouth-hooklets apparently three pairs: two near the jaws of which the ventral pair is the heavier, the third pair lateral in position, heaviest of all. There are a number of sensory papillæ around the mouth-parts and antennæ. The antennæ are small, situated close together above the jaws, of the usual form (see Fig. 81).

The prothoracic spiracles are slightly elevated, blunt, short, horn-shaped as seen from the side (Fig. 81, *g*), the semi-circular slit apparently guarded by six, blunt teeth, one of the median ones emarginate or imperfectly divided (Fig. 83). The posterior

respiratory appendage (Figs. 84, 85) is a fourth longer than broad, testaceous brown, ringed about mid-length, thence slightly constricted. The spiracles (*a*) moderately long, somewhat elevated above the surface; the inter-spiracular spines (*b*) short, blunt, spur-like, rather prominent. Dorsal spiracular spine (*c*) short, compressed; its breadth about equal to diameter of the approximate circular plate (*d*).

These larvæ were found, full-grown, at Cedar Point, July 7, 1911. The larval stage continued indoors to July 11 and 12.

They were collected on the Poplar or American Aspen (*Populus tremuloides* Mx.) in the well-known, characteristic galls on the ends of the twigs, made by the aphid, *Pemphagus vagabundus* Walsh.

These galls are large, commonly two inches in diameter, very irregular in shape, the outer surface thrown into numerous deep convolutions. Their structure is such that they enclose a number of small, partially separated chambers, the thick walls of which are lined by the aphids.

There are usually several openings to the many-chambered gall, but it is pretty certain that the larvæ do not ordinarily migrate from gall to gall; although there is a bare possibility that they might do so if the food supply in any one ran out. They are negatively heliotropic, seeking out protected dark corners when kept in confinement. They feed on the body contents of the aphids; hence there is commonly an abundance of food at hand and, as the volume of the chambers in the gall is small, there is no occasion, and little opportunity, for active movements. In correlation with this we find the larvæ very sluggish, lying quietly for hours or even days, even though unfed. Since migration from one of these galls to another would commonly involve traveling for several feet, it seems to me very likely that the larva or larvæ are dependent on the aphids within the single gall in which they begin their larval existence. They are very well protected within the poplar galls and I found no parasites affecting them. It would seem that they are paying for their well-fed, well-protected, sedentary life in sluggishness, and are possibly on the road to degeneration.

Pupa.

Dimensions, average of 5: Length 7.2 mm., height 3.5 mm., width 3.8 mm. These puparia (Figs. 86, 87) are exceptionally inflated dorsally, the ratio of height to length being greater than in any of the other species I have examined. It is characteristic of them also that the posterior inflation is equal to, or greater than, that anteriorly; in outline, as seen from the side, the dorsal half of the puparium makes an almost perfect semi-circle. The ventral line is sinuate. The respiratory appendage (*a*) projects from

the lower posterior part. From above, the outline is sub-ovoid, broadest in front of the middle, thence narrowing gradually to the posterior third; whence the puparium is strongly and unevenly compressed to the tip of the respiratory appendage.

Color at first grayish brown, sometimes marked with oblique patches of black; posterior breathing appendage darker. As the pupa approaches metamorphosis the anterior end darkens to deep reddish-brown in the region of the eyes; while on the posterior half, the three principal, yellow abdominal bands of the adult become visible through the transparent wall.

The segmental spines remain, as in the larva, very inconspicuous. The posterior breathing appendage also retains its characteristics.

Of three specimens taken on July 7, one pupated July 11, the other two the following day. The former emerged as adult July 18, the latter two July 20. Hence the duration in the pupal stage was 7 to 8 days. I did not determine the place of pupation and so cannot say whether, in the field, this stage is passed within the galls or not. Examination of a number of the galls later in the summer failed to reveal any puparia.

Adult.

Male:"Length, 11 to 12 mm. Face and cheeks wholly yellow, antennæ reddish yellow, the third joint somewhat brownish above, but little longer than wide, the arista black. Frontal triangle with a small black spot in the middle, gray pollinose along the eyes, black pilose in the middle. Dorsum of thorax shining metallic green, with light colored pile; lateral margins distinctly yellowish pollinose. Scutellum wholly yellow. Abdomen black, the anterior half of the black bands sub-opaque, the three principal bands very broad, attaining the lateral margins in nearly their full width; first band interrupted, the spots narrowly separated, with their inner ends rounded; second and third bands with a narrow but deep emargination in the middle behind; fifth and sixth segments with a yellow hind margin. The black forms narrower bands than the yellow, and does not quite reach the margin. Legs yellow, the tip of hind tibiæ and their tarsi brownish. Wings hyaline, the stigma yellowish.

Female: "Front metallic green, yellow below, on the lower half with yellowish pollen. Yellow spots of the second abdominal segment larger, more nearly square, and only narrowly separated."
—Williston, Synop. N. A. Syrphidae, p. 86.

Eristalis aeneas Scopoli.

(Plate V, Figs. 131 to 141 and 145 to 148; and Plate IV, Figs. 149, 150.)

Egg.

The egg of *Eristalis æneas* was not found but that of its near relative *E. tenax* was studied and is figured in Plate V, Fig. 142.

These eggs are much larger than those of most of the aphidiphagous species studied, but are equaled in size by the egg of *Didea fasciata*. Length 1.6 mm., diameter 0.4 mm., elongate ovoid, slightly bent, rounded at the ends, the anti-micropylar end the larger. The shell shows the usual sculpturing but the radiating arms between the main bodies are much less conspicuous or at times apparently wanting (Fig. 143). There are about 65 bodies the length of the egg, about 100 around it at the middle. Each body is about two or three times as long as broad, with 9–13 short arms radiating from it. The bodies are well separated from each other. The color is the usual chalk-white.

A female of *E. tenax* was taken at the city sewage disposal plant while ovipositing over filth, September 23. Within an hour and a half after being taken she had deposited about 100 eggs. Part of these were deposited in more or less scattered positions; the great majority, however, in one or two masses, in which they were ranked on end, their sides closely apposed. They were floated over a vial of water, and within 24 hours a considerable number of them had hatched and were to be seen crawling on the vial or wriggling in the water.

Larva.

The young larva of *E. tenax* (Fig. 144) is scarcely longer than the egg except for the projection of the posterior respiratory appendage. Including this structure the length, 2 or 3 hours after hatching, was 2.5 to 3 mm. The larvæ are sub-cylindrical but attenuated at the posterior end to the breathing tube (Fig. 144, *d*). They frequently show a prominent hump dorsally in the posterior third of the body. Antennæ (*a*), prolegs (*b*), tracheal trunks (*c*), and other larval structures are present but these are described below for the larva of *E. æneas*.

The mature larva of *Eristalis æneas* (Fig. 131) resembles in a general way the well-known rat-tailed larva of *E. tenax*, but is considerably smaller.

The body is soft, slug-like, elongate-oval or sub-cylindrical in shape, about 13 to 15 mm. long by 3 to 4 mm. broad and 2 to 3 mm. high; these dimensions varying with the different positions assumed by the motile larva. The anterior end is commonly

retracted so as to be roughly truncate. At the posterior end the last segment tapers rather abruptly to the posterior respiratory appendage. This appendage (Fig. 131, *d*) is tube-like and very long. Its diameter near the body is usually about 0.5 mm. while at the end it is less than one-half this width. Its length varies extensively; it is seldom retracted to less than 5 mm. and may be elongated in exceptional instances to 100 mm. or nearly four inches. A more usual elongation is about 15 to 30 mm. The color of the larva is a dirty gray or brown.

The body-wall is soft, flexible, more or less greasy or slimy to the touch, and translucent. The integument has a number of transverse folds which terminate laterally in a moderately distinct lateral carina running the full length. These folds fall into a number of groups, between which the integument is smooth, each group consisting of about five transverse elevations or wrinkles. Near the middle of these groups of folds one can detect double, flexible hairs (Fig. 136, *a*), about twelve in number situated in a transverse row. The lateral margins of the body also are constricted between these groups of folds.

For these reasons I am convinced that these divisions of the body represent somites or body-segments. I suspect that the bifid, flexible hairs are homologous with the single, usually rigid, segmental hairs of the aphidiphagous forms which are similarly located with reference to segments. Determined in this way the body shows seven similar and perfect segments when in a retracted position. To these may apparently be added two posterior ones which bear the long respiratory tube and on which the anus opens ventrally. Immediately in front of these seven similar segments open the anterior respiratory cornua of the larva, which would represent a tenth segment. The remaining ones in front are indefinite, retractile, and bear the antennæ, a mouth-hood, and, within the buccal cavity, certain chitinized mouth-parts. If, as in the case of the aphidiphagous species, we consider the anterior larval spiracles as representing the prothoracic segment and allow, as in that case, two segments for the head, then this segment becomes No. 3, the last one of the seven would be No. 10, and the ones bearing the anus and respiratory appendage would make twelve in all.

The mouth-parts of the larva are located internal to a hood-like, striated, chitinous termination of the oesophageal framework. (Figs. 138, *b;* 139). They are peculiar structures which I have been unable to homologize with the parts in the aphidiphagous larvæ, but which seem to me to represent these structures in a degenerate condition. They are represented in Plate ——, Figs. 139, 140, 141, perhaps better than they can be described. Of the parts there figured only the hood reaches the surface or can be seen without dissection.

The antennæ (Fig. 138, *a*) are located close above the buccal cavity and seem to consist of a basal fleshy segment and two, slightly-elongated pieces side by side at the apex. These are located on a fleshy, partly bifurcated process of the head segment. The small pieces at the tip are not alike in appearance; the one nearer the middle line is abruptly constricted near its middle, beyond which it continues with less than a fourth its diameter at the basal half. The outer one is of nearly equal diameter to the truncate apex.

The integument as a whole is provided with short, flexible, light-colored hairs (Fig. 136, *b*), which are specialized on the prolegs, on the posterior breathing appendage, and also into the segmental hairs.

The anterior spiracles (Figs. 131, *b;* 132), are borne on a pair of horn-like prominences which are capable of considerable extension but are usually rather closely retracted. The tip is marked by a sub-circular opening guarded by twenty rounded lobes.

The pro-legs, of which there are seven pairs, are simply ventral, knob-like projections of the body surface, over which the ordinary integumental vestiture has become specialized (Fig. 138, *c*). The hairs are larger, heavier, and decidedly curved and retrorse; there are several sizes of these hooks on each pro-leg. They are very efficient organs of locomotion in soft mud or over hard surfaces, and in the present case doubtless enable the larva to migrate to the place of pupation as described below.

The anal opening is located ventrally near the base of the "tail." It is slit-like, and is very peculiar in that it opens among a group of soft, retractile, radiating flabellæ about a dozen in number. These flabellæ may be entirely retracted so as to be invisible, and are at intervals rapidly unfolded presenting a beautifully symmetrical arrangement (Fig. 137). Buckton suggests that they may have a renal function.

The posterior respiratory appendage (Fig. 131, *d*) is a most remarkable and highly specialized organ which enables the larva to feed at various depths beneath the water without coming to the surface for its ærial respiration. The spiracles are situated distally on an elongated tube-like appendage, which is extensile and retractile in a telescopic manner. It is composed of three sections of different caliber and superficial appearance, each double in nature, enclosing two tracheæ, but fused medially to the tip, never forked. These sections are capable of sliding one within the other. The one next the body is the largest, nearly cylindrical, half a millimeter in diameter, transversely wrinkled and bearing numerous, soft, concolorous, blunt hairs, similar to those of the body surface (*the integumental hairs*) but only about half as large (Fig. 134). The middle segment of the posterior appendage is about two-thirds the diameter of the basal one, and is

marked by irregular longitudinal ridges bearing, in longitudinal lines, very short, sharp, recurved hairs, broad at the base (Fig. 135). These alternate on any two adjoining ridges. The terminal segment is smooth, shiny, with its surface transversely ridged in a manner which, under low magnifications, suggests a trachea. When more carefully examined, however, the two trachea which run the full length of the tube are easily seen through the outer walls of this segment (Fig. 133, *a*).

The tube terminates in a rounded, convex tip which seems to be perforated by two small semi-circular slits. It is ornamented with four pairs of tiny, delicate, feather-like appendages which open out radially. (Fig. 133, *c*). These are probably lubricated in some way for they seem to repel the water and are not easily submerged. These feather-like structures may be homologous with the inter-spiracular hairs or spines of the aphidiphagous larvæ.

These larvæ can progress through the water by undulatory constrictions of the body, or creep over submerged or exposed objects by the aid of their pro-legs. (Buckton believed that in *E. tenax* the tail is used by pushing from behind to aid the grub in penetrating into soft mud.)

Numerous larvæ were collected in the evaporating vats at the Columbus sewage disposal plant in September. They were found in large numbers swimming about in the very putrid, watery material, near the surface where a kind of scum had collected. Their food is undoubtedly the various decaying materials brought in with the sewage.

These are very interesting animals to watch under a low power microscope: the peculiar undulatory creeping or swimming movements, the retraction and elongation of the breathing appendage, the occasional unfolding of the flabellæ about the anus, and the peculiar opening out and introverting of the anterior segments, lips, antennæ, mouth-hood, etc., besides the action of the viscera all being clearly visible, and fascinating objects for study.

Pupa.

While the change from larval- to pupal-stage in the aphidiphagous forms is not sharply defined, it is clearer there than in the rat-tailed form as illustrated by *E. æneas;* because in the latter case, the shortening and dorsal inflation are proportionately not so great.

Length 8–10 mm., height 3–4.5 mm., width 3.5–4.5 mm. Shape elongate-ovoid, much like that of the larva but considerably shortened, and somewhat inflated dorsally; so that as seen from the side (Fig. 145) the dorsal line is strongly convex in front and behind, weakly so along the middle. The ventral line is

nearly straight. From its posterior end arises the tail-like respiratory appendage (Fig. 145, *c*) which is usually curved anteriorly above or around the body. It is commonly shortened to a length of 8 to 10 mm. of which the basal segment often forms about two-thirds, the terminal one usually being second in length. The tracheal tubes from these appendages soon become constricted off a short distance within the main body of the puparium and are not functional during most of the pupal stage.

At the approach of pupation there appears under the larval skin, about one segment back of the anterior or larval respiratory cornua, (Fig. 131, *b;* 145, *a*), a pair of rounded darkened areas. These soon become elevated to a length of about 2 mm.; their diameter being about 0.25 mm., rather uniform to near the tip where they round off (Fig. 145, *b*). They are provided on the distal three-fourths or four-fifths of their length with several hundred, short, rounded tubercles (Fig. 147). These tubercles are somewhat collected into groups, and, especially along the anterior-median surface, are absent over a longitudinal stripe. When highly magnified each tubercle is seen to be ornamented on the tip with about 8 or 9 radial elevations, which I take it are the spiracles. (Fig. 148). The elevations as a whole are called the pupal respiratory cornua. Internally to the puparium they continue as large trachea, which attach to the dorsal part of the prothoracic segment of the developing nymph (Fig. 146, *a*). There is thus quite clearly a special provision for pupal respiration.

These might be considered homologous with the prothoracic spiracles of the adult fly; and since they penetrate the puparium about one segment back of the anterior larval respiratory cornua, it might seem improper to consider the larval segment which bears the latter the prothoracic. Nevertheless, it does not seem to me that the point at which these pupal cornua emerge should be considered of much significance. The larval skin at this time is much distorted out of its normal shape by contraction and inflation and it would not seem that segmental homology could longer hold.

The larval respiratory cornua (Fig. 145, *a*) become fixed at a length of about 0.75 mm. their diameter being slightly less than that of the pupal cornua just described. They are recurved slightly to a sharp point. The sub-circular group of rounded lobes at its tip in the larva (Fig. 132), become obscure in this stage. Internally the trachea from these cornua are constricted off and have no connection with the pupa, at least in its more advanced stages.

The buccal cavity, antennæ, etc., are retracted within the puparium a short distance back of the anterior end where the dorsal elevation begins. Internally the œsophageal framework is flattened against the ventral wall of the puparium from which the

pupal body becomes separated. The position of the seven pairs of pro-legs and of the anal opening are shown as scars on the puparium (Fig. 145, *e*, *d*).

The color of the puparium with the pupa enclosed is a very dark brown. When empty and dried it is brittle, and a very pale ashy-brown in color. The larval wrinkling remains visible to a slight extent.

Pupæ of this species were found in abundance at the sewage disposal plant the middle of September. The walls of the vats are of cement and are, much of the time, six or eight feet higher than the level of the water. They are surmounted by an iron railing. In the angles of this railing, or on the sides of the wall, wherever a crevice or angularity presents itself, numbers of puparia were found massed together and considerably overgrown with webs of spiders. During the winter the empty puparia in these locations form excellent nests for the spiders.

Buckton, writing about *E. tenax*, states that the larvæ buried themselves in soft mud, each forming a small dome over itself, and so pupating under a shallow covering of mud. This method of pupation would be a protection against drought. The pupæ taken about the middle of September emerged as adults September 26, so that the duration in this stage was at least ten days to two weeks. During the winter all the puparia that could be found were empty or contained dead nymphs. Does the fly pass the winter in some other stage, or can it be that the puparia left exposed cannot winter and that normally they bury themselves in mud? If the latter is true, other puparia at this place may crawl farther and bury in the soil.

Adult.

Description slightly modified after Williston, Synopsis N. A. Syrph. pp. 161, 162.:

"Male and female: Length 8 to 10.5 mm. Dark metallic green, wholly shining. Thorax sometimes with a bluish reflection. Eyes brownish, spotted with small round dots of darker (Plate IV, Fig. 150). [This character sometimes disappears after death]. The eyes are nearly bare, very slightly pilose near the top. Face and front with grayish pile and pollen, a small spot on the tubercle and the cheeks narrowly shining. Antennæ brown, dorsal part of third joint darker; often the first two joints yellowish; arista bare. Thorax and abdomen with obscure yellowish pile. Dorsum of the thorax in the female with five grayish-white stripes, the middle one slender, linear, the two lateral ones broader (Plate IV, Fig. 150). Scutellum with the same dark metallic green. Tibiæ at the base, sometimes for nearly half their length, light yellow; middle, sometimes all the metatarsi, yellowish; the femora, except the tip, black; distal portion of tibiæ blackish brown. Wings hyaline."

Didea fasciata Macquart, var. **fuscipes** Loew.

(Plate IV, Fig. 17.)

(An addition to the life-history notes on this species published in The Ohio Naturalist, Vol. XI, No. 7, pp. 337–341, May, 1911).

Egg.

Elongate oval in outline, sub-cylindrical, but flattened ventrally and arched slightly dorsally; broadest about the middle. Length 1.3 to 1.7 mm., diameter 0.4 to 0.6 mm. Color chalk white. The chorion is sculptured in a characteristic manner. The projecting bodies are close together, not highly elevated, each one two to four times as long as broad. There are 55 to 60 of these bodies lengthwise of the egg and 80 to 100 around it at the middle. The egg of *Didea* differs from all the others I have seen in that the projecting bodies are not smooth on the top but each one has a small number (6–10) of more or less angular, irregular-shaped, pit-like depressions hollowed out of it. These are so arranged as to leave between them an elevated part of the body with more or less parallel sides. The whole effect is to give the arm-like network appearance over the main body somewhat like that between these bodies, without the outlines of the bodies being obscured. The arms between these bodies are irregular, slightly branched, for the most part rather short, sometimes long, from 10 to 15 radiating from each body.

Eggs already hatched and larvæ apparently 5 or 6 days old were taken on sycamores at Columbus, September 28, 1911. A number of eggs, not hatched, and nearly full-grown larvæ were taken October 7.

The eggs are scattered singly along the under side of the low, spreading, more or less horizontal branches of the sycamore (*Platanus occidentalis* L.) at a time in autumn when the colonies of aphids (*Longistigma caryæ* Harris) are just being established, or even in anticipation of their arrival. Indeed it seems to me likely that the latter is usually the case. Certainly many eggs can be found in branches where no aphids are yet to be seen. They are laid flat down, glued by the posterior half of the ventral side to the bark, and are of such a size and color as to be readily seen on close examination with the naked eye.

EXPLANATION OF PLATE IV.

Figures 81–89 *Syrphus xanthostoma* Wills.

Fig. 81. Antero-ventral view of head of larva much enlarged; *a*, sensory papillae; *b*, antenna; *c*, upper jaw; *d*, outer pair of mouth-hooks; *e*, other mouth hooklets; *f*, lower jaw; *g*, anterior spiracles or larval respiratory cornua; *h*, oesophageal framework, within.

Fig. 82. Lateral view of larva, x 6; *a*, median segmental spines; *b*, posterior respiratory appendage.

Fig. 83. End view of anterior spiracle, highly magnified.

Fig. 84. Dorsal view of posterior respiratory organ x 40; *a*, one of the three pairs of slit-like spiracles; *b*, one of the inter-spiracular spurs; *c*, the median dorsal spiracular spur; *d*, the circular plate.

Fig. 85. End view of posterior respiratory organ, x 50; lettering as in Fig. 84.
Fig. 86. Dorsal view of puparium x 3; *a*, posterior respiratory appendage.
Fig. 87. Lateral view of puparium x 3.
Fig. 88. Scutellum and abdomen of female from above, showing color pattern, x 5.
Fig. 89. Wing of male, x 7.

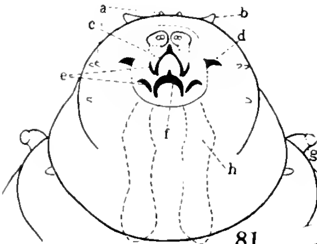
Figures 149, 150 *Eristalis aeneas* (Fab.)

Fig. 149. Wing of male x 7.
Fig. 150. Dorsal view of head and thorax of female showing characteristic spotting of the eyes, and pollinose thoracic pattern, x 5.
Fig. 17. *Didea fasciata fuscipes;* characteristic sculpturing on chorion of egg.

EXPLANATION OF PLATE V.

Figures 142–144, inclusive, *Eristalis tenax* (Linne) all the others of *Eristalis aeneas* (Fabricious). See also Figs. 149, 150

Fig. 131. Dorsal view of mature larva x 9; *a*, antenna; *b*, anterior larval respiratory cornua; *c*, the large tracheal trunks; *d*, the posterior respiratory tube or "rat-tail." To avoid a confusion of detail the vestiture is not represented in this figure.
Fig. 132. The anterior larval respiratory cornua, much enlarged, dissected out to show the large trachea leading from it.
Fig. 133. Distal end of respiratory tube highly magnified, showing wrinkling on outside, the two inner tracheae (*a*), the spiracles at the tip (*b*) and the delicate, feather-like appendages (*c*).
Fig. 134. A small area of the basal segment of the tube much enlarged, showing the character of the vestiture and wrinkling.
Fig. 135. A small area of the median segment of the tube much enlarged, to show the character of the vestiture and wrinkling.
Fig. 136. *a*, one of the bifid, segmental hairs of the larva, and *b*, one of the integumental hairs of the body drawn to the same scale as Figs. 134 and 135.
Fig. 137. The anal opening of the larva (*a*) with the retractile flabellae (*b*), much enlarged.
Fig. 138. Ventral view of the head of the larva much enlarged; *a*, antenna; *b*, mouth hood; *c*, the first pair of pro-legs.
Fig. 139. Ventro-lateral view of hood and oesophageal framework dissected out, much enlarged.
Fig. 140. The chitinized mouth-parts internal to the hood from the side; *a*, hooklets, possibly homologous with those of aphidiphagous larvae; *b*, mandible-like structures; much enlarged.
Fig. 141. The same as Fig. 140, ventral view.
Fig. 142. Eggs of *E. tenax*, x 17, showing method of ranking in oviposition.
Fig. 143. Sculpturing of chorion of egg of *E. tenax*, highly magnified.
Fig. 144. Larva of *E. tenax* a few hours after hatching; *a*, antenna; *b*, one of the prolegs; *c*, tracheal trunks; *d*, posterior respiratory appendage, x 17.
Fig. 145. Puparium of *E. aeneas* from the side, x 4; *a*, anterior larval respiratory cornua; *b*, pupal respiratory cornua; *c*, posterior respiratory appendage; *d*, anal flabellae; *e*, pro-legs.
Fig. 146. Nymph, or developing imago, dissected out of puparium to show connection of tracheae from pupal respiratory cornua to prothorax (*a*); *b*, knee of front leg; *c*, wing-pads; *d*, scutellum; x3.
Fig. 147. Pupal respiratory eornua very much enlarged showing arrangement of spiracular papillae.
Fig. 148. Two of the papillae of the pupal respiratory cornua showing radiating structures believed to be the spiracles.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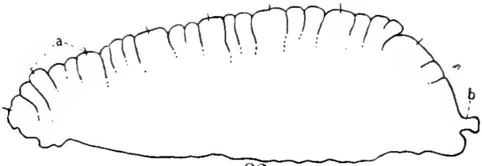
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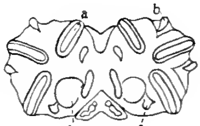
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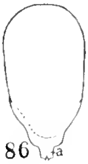
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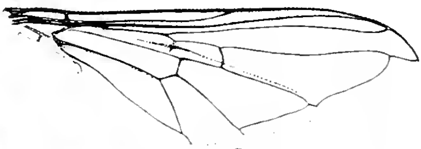
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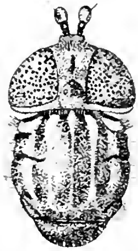
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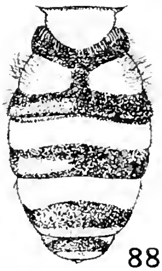
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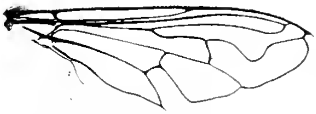
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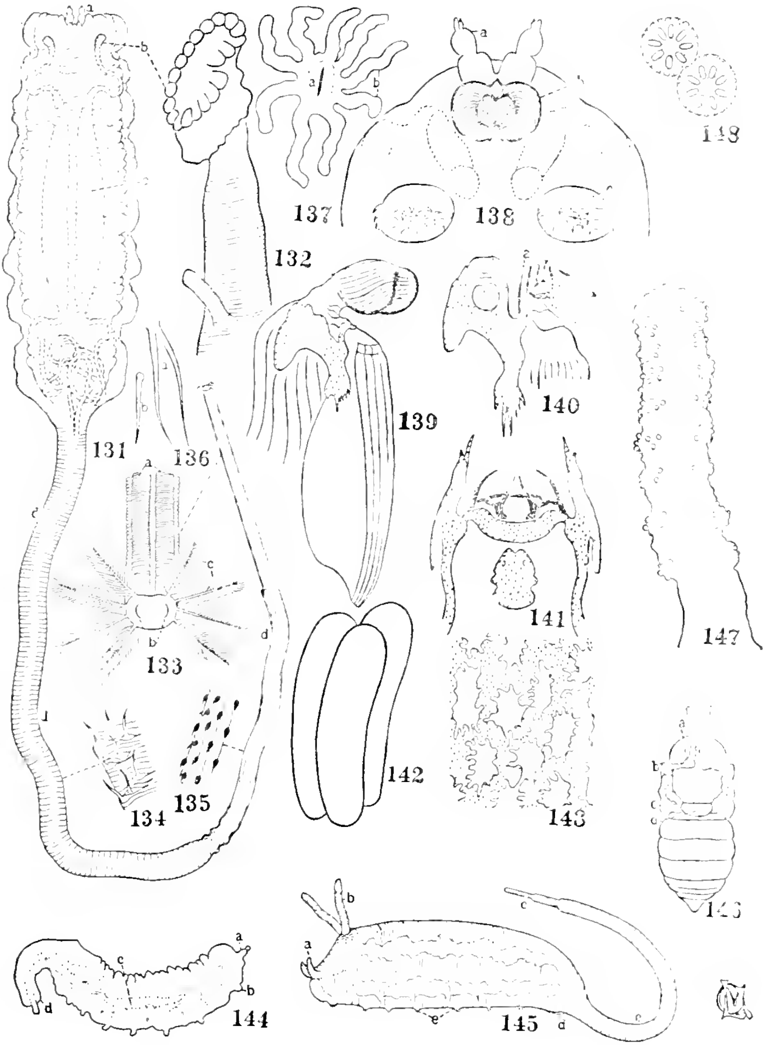
METCALF on "Life Histories of Syrphidae."



METCALF on "Life-Histories of Syrphidae."

ADDITIONS AND CORRECTIONS TO THE ODONATA OF OHIO.

Jas. S. Hine.

The "Odonata of Ohio" by Dr. David S. Kellicott was published in March, 1899. At that time 98 species had been taken in the state and all were represented in Professor Kellicott's collection. Anax longipes Hagen was mentioned as a possible member of Ohio's fauna, but no specimens had been procured and we have no further information in regard to it at the present time.

A few misstatements have been noted in Dr. Kellicott's articles concerning dragonflies, largely unavoidable at that time because of the small amount of work that had been done on some of the genera. Recent investigations have revealed the fact that some additional species were at hand in 1899 but were associated with nearly related ones on account of not being described. Finally a number of species not previously reported for Ohio have been collected in various sections of the state and by various collectors, most usually while engaged in preparing general faunal collections.

On account of the few misstatements and the several additions that have been made to the number of species taken within the limits of the state, it seems desirable at this time to print some statements for the purpose of bringing the list of Ohio dargonflies up to date. In Volume I of the Ohio Naturalist, page 13, are given a few additions and corrections, but since some of these should be mentioned again, I have thought best at this time to give such information as has been collected since the appearance of The Odonata of Ohio.

An attractive species of Enallagma was considered an undescribed species and named Enallagma fischeri by Dr. Kellicott. After studying a large amount of material Mr. E. B. Williamson came to the conclusion that E. fischeri is the same as Agrion antennata Say and Dr. Calvert concurred. I believe that Williamson is correct in his conclusion in this matter, but due deference to Dr. Kellicott merits the statement that Say's description is rather brief and does not fully explain distinctive characters. After one is well acquainted with the dragonfly fauna of the section where Say procured his specimens it is possible to reach the proper conclusion by the process of elimination. In other words there appears to be no other species in this region that answers so well Say's description as the one in question.

At the time when Dr. Kellicott did his work on Ohio dragonflies some of the species of the genus Gomphus were not well defined, consequently a few of his determinations have been

proven incorrect and the following statements may be made in order to harmonize his publications with recent conclusions of the foremost students of Odonata.

In Volume XII of Entomological News, page 65, Dr. Calvert gives a comparative study of three closely related species of this genus. After studying Ohio material as well as much material from other sections he announces that Gomphus fraternus var. walshii as published in Jour. Cin. Soc. Nat. Hist. XVIII, p. 107, and Gomphus externus in Odonata of Ohio, page 60, should be changed to Gomphus crassus Hagen.

Gomphus intricatus mentioned in Agricultural Student, Vol. III, page 143, and Gomphus sp. Jour. Cin. Soc. of Nat. Hist., Vol. XIX, page 67, are referable to Gomphus notatus Rambur.

Gomphus notatus Ramb. as used by Dr. Kellicott in Jour. Cin. Soc. Nat. Hist., Vol. XIX, page 67, is Gomphus plagiatus Selys, as we know it at the present time.

Celithemis fasciata Kirby, Odonata of Ohio, page 104, and in Dr. Kellicott's other writings, is referable to Celithemis monomelæna Williamson, which was described as a new species in Ohio Naturalist, Volume X, page 153, and the reader is referred to this paper for particulars.

The following changes and statements are supplementary to the Odonata of Ohio and are made for the benefit of future students and collectors of the order in the state:

Enallagma antennata (Say) to be used instead of Enallagma fischeri Kellicott.

Gomphus crassus Hagen to be used instead of Gomphus externus Selys.

Celithemis monomelæna Williamson to be used instead of Celithemis fasciata Kirby.

Gomphus lividus Selys should stand as it is, since Gomphus sordidus Hagen is now considered a synonym.

Gomphus plagiatus Selys, spoken of with some doubt, is correct as given.

Gomphus notatus Rambur is correct as given and additional Ohio species have been procured.

The following species have been taken in the state and should be added to the Ohio list:

Calopteryx angustipenne (Selys), was procured near Loudonville by Osburn and Parker, June 10, 1899. Additional specimens were procured at the same place in June, 1900.

Lestes eurinus Say, taken in Portage County, June 3, 1900, by E. B. Williamson. Numerous specimens of both sexes taken on Cedar Point, Sandusky, by the writer, July 10, 1900.

Gomphoides obscura (Rambur), taken by R. C. Osburn, at Ironton, June 1, 1899. Additional specimens taken by myself at Vinton, June 10, 1900.

Erpetogomphus designatus Hagen, taken by Williamson along the White Water River near Harrison, July 26, 1903. Calvert mentions this species as a member of the Ohio fauna in Biol. Cent. Amer. Volume on Odonata, page 167. Williamson states that he has seen specimens in Dury's collection, taken at Cincinnati.

Gomphus viridifrons Hine. In OHIO NATURALIST, Volume I, page 13, this species is listed under Gomphus abbreviatus (?) Hagen. Specimens procured near Loudonville by J. B. Parker and R. C. Osburn, June 10, 1899. The species was common at the same locality June 14, 1900.

Gomphus amnicola Walsh, taken along the Little Miami River at Cincinnati by Chas. Dury, May 5, 1899, and July 10, 1903. Along the Ohio River by the same collector, July 25, 1911.

Boyeria grafiana Williamson. This species was included under B. Vinosa (Say) in The Odanata of Ohio. Williamson published a description of it as a new species in 1907, Entomological News, XVIII, page 1. A male, taken at Orwell, Ohio, September, 1894, by E. E. Bogue, is in the Kellicott collection.

Aeschna mutata Hagen. Specimens taken by Osburn and Hine at Stewart's Lake, near Kent, O., June 22, 1900. Listed in OHIO NATURALIST, Vol. I, page 14, as Aeschna verticalis Hagen.

Nasiæschna pentacantha (Rambur) was taken near Kent, O., June 21, 1900. In company with R. C. Osburn we procured three pairs of the species. Others were seen.

Neurocordulia obsoleta (Say) has been taken at Cincinnati, by Chas. Dury and his associates in different years. A male specimen in the Kellicott collection was taken at Cincinnati, June 15, 1899.

Neurocordulia yamaskanensis (Provancher) was procured on Rattlesnake Island, in Lake Erie, June 28, 1900, by Prof. H. Osborn

The additions here enumerated bring the number of species of dragonflies actually collected in Ohio up to 109. There is no doubt but that more additions can be made by thorough collecting in all parts of the State.

CARNIVOROUS PLANTS OF OHIO.

Amy Williams.

In Ohio we find representatives of all the main types of insectiverous plants:

First those having traps or chambers into which the insects go and are caught; second, those which show definite movements in response to a stimulus caused by contact with the animal; and third, those which have neither pitfalls nor movements, but which have viscid-pubescence or viscid areas on their leaves or stems, on which the insects are caught.

In the first group we find:

Sarracenia purpurea L.
Utricularia cornuta Mx.
Utricularia vulgaris L.
Utricularia intermedia Hayne.
Utricularia minor L.
Utricularia gibba L.
Silphium perfoliatum L.
Dipsacus sylvestris Mill.

Sarracenia purpurea, Pitcher-plant, has its leaves converted into deep tubular pitchers, and arranged in rosettes, which rest on the ground, and from there curve upward. They are somewhat inflated at about their middle, but get smaller again near the opening where they pass into small laminae. These are threaded by red veins, which often form a very striking pattern. The liquid remains in the pitcher for an indefinite period, as there is little chance for evaporation in the hollow tubes. Insects alighting on the short lamina above the opening or crawling up from below, slide down readily into the pitcher because of the smooth, stiff, reflexed hairs. After they are in, their attempts to escape are entirely futile, because of the peculiar arrangement of downward pointing, stiff hairs, which line the throat and prevent them from crawling up. They finally drop into the liquid collected in the bottom, where they drown and may then be absorbed by the plant.

The Utricularias, Bladder-worts, are aquatic plants rooted in the mud or suspended in the water, and according to season, either sink down to the bottom or rise to just beneath the surface. In winter, when animal life is gradually disappearing from the upper layers of the water, the tips of the floating stems enlarge and form spherical winter-buds, which sink to the bottom during the winter. In the spring these buds elongate and come up to the surface. Here they put out two lateral branches which are covered with leaves and little bladders. The bladders are pale-green and partially transparent. They are somewhat flattened on the sides and have a convex dorsal surface and a slightly

curved lateral surface. Their openings are in the shape of mouths having their borders fringed with stiff, tapering bristles. The under lip of the mouth is very thick and has a cushion extending into the interior of the bladder. The upper lip is very thin and from it a transparent valve comes down to meet the inner edge of the cushion, thus closing the opening. By pressing against this valve minute plants or animals are able to enter the bladder from which it is impossible for them to escape, because of the valve.

Silphium perfoliatum, Indian-cup, has its leaves arranged opposite each other on the stem, and united to form a cup. This cup is filled with water, probably partly rain and partly some excretion from the plant itself.

Dipsacus sylvestris is a coarse herb having its leaves arranged opposite each other, forming a cup to catch water, much like the Silphium. Their edges and mid-ribs are covered with prickles.

In the second group are:

Drosera rotundifolia L.
Drosera intermedia Hayne.

The different forms of Drosera, Sun-dew, are usually rooted in damp, mossy soil or bogs. The way in which these plants catch their prey is by means of fine red filaments which are clavate on the free ends and tipped by a drop of fluid. These filaments stand out from the upper surface of the leaf, the under side being smooth and without hairs. They are of unequal length, the longer ones being near the outer edge, the shorter ones in the center. There are on one leaf, sometimes as many as two hundred of these tentacles. The clavate head is really a gland which secrete a thick, sticky, sweet fluid. It is remarkable that in making experiments, by placing bits of non-nitrogenous substances upon the leaf, the movement is scarcely perceptable, in response, while when insects alight upon the surface, the process immediately begins. In many instances the leaf itself becomes concave, so that when the tentacles are down, it has the appearance of a closely doubled fist. When the insect alights near the center of the leaf it is covered by the secretion of all the tentacles.

Those in the third group are:

Silene antirrhina L.
Silene antirrhina divaricata Rob.
Silene virginica L.
Silene noctiflora L.
Silene regia Sims.
Silene armeria L.
Silene conica L.
Silene caroliniana Walt.
Tricuspis seslerioides (Mx.) Torr.
Carduus muticus (Mx.) Pers.
Carduus odoratus (Muhl.) Port.
Parsonsia petiolata (S.) Rusby.
Polanisia graveolens L.
Circaea alpina L.

The plants of this group excrete a sticky substance by which insects are often captured in large numbers.

In the Silenes, Tricuspis, Parsonsia, Polanisia and Circaea the secretive and absorbing glands are on the stems, while in Carduus the viscid substance is excreted on the bracts of the involucre. In this case the excretion acts more as a protection to the flower against crawling insects. In certain western species of Carduus the glutinous secretion on the bracts is so abundant that it is impossible for any crawling insects like ants to pass over it to the flowers above. The species in Ohio have the glands on the bracts and insects were observed adhering to them but they are much less prominent.

CALOPLACA PYRACEA (ACH.) TH. FR., A CRUSTACEOUS LICHEN ON THE SANDSTONE SIDEWALKS OF EAST CLEVELAND, OHIO.

Edo Claassen.

Owing to the frequent rains last summer more algae seemed to grow on the sidewalks than ever before. They were yellowish-green, represented a species of Cystococcus, and occasionally covered the entire surface of the stones. Here and there small specks of a grayish color appeared on them, a fungal growth several mm. in diameter. The mycelium spread out and continued to do so while its central part began to disappear. In these centers algae again commenced to grow while the mycelium stretched out more and more, surrounding the algae like a ring continually increasing in size. It frequently happened that some mycelium located itself on the central part of this algal layer, thus apparently repeating the former process. It was on these layers of mycelium that apothecia were forming in great numbers. They were yellow to orange-yellow with their rim-like external part, the so-called exciple, lighter in color. When young they were somewhat convex but later on mostly flat.

The apothecia contained asci in a more or less mature condition. The spores were very seldom simple, except when quite young and filled with granular protoplasm, but usually even when rather young they were two-celled. Nearly fullgrown spores as well as ripe ones were always two-celled. Although the two-celled spores of this lichen are said to be generally "polar-bilocular," none of this type could be ascertained in the specimens examined.

All the lichen specimens were concentrically arranged on the stones wherever they had space enough to spread; when full grown their diameter reached 50 to 70 mm. or even more. In the central part of an examined specimen was found an algal layer of

40 mm. diameter, surrounded by a mycelium 15 mm. wide. In another specimen of about the same size the central part of the algal layer was covered again by a mycelium 12 mm. in diameter, so that now this mycelium was surrounded by an algal and a fungal layer in the shape of concentric rings. The apotheeia in the last mentioned case were distributed as well on the inner as on the outer mycelium.

The apothecia are usually provided with a great number of asci, each containing 8 colorless, more or less elliptical spores, which are liable because of their small size (11–16x7–8 mic.) to be blown to long distances by the wind.

On finding a proper substratum, as seems to have been the case here, the algae on the moist sandstone, they reproduce innumerable new plants. They lead a symbiotic life, apparently without either benefit or harm to the algal symbiont, but certainly with benefit to the fungal part.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, November 4, 1912.

The club was called to order by Pres. W. M. Barrows. The minutes of the last meeting were read and approved.

The principal business of the evening was the election of officers. The nominating committee reported the names of two candidates for each office and the following were elected:

President, W. G. Stover

Vice-President, Blanche McAvoy.

Secretary-Treasurer, Marie F. McLellan.

Following the election came the president's address on "Some Recent Work Along the Line of Mendel's Law."

Prof. Barrows discussed Mendel's original idea and showed that the results of modern work have been slightly different from Mendel's expectations. The purity of germ cells and their unchangeability have been questioned. It has also been shown that units are not physiologically separate, but react on one another.

He then took up the phenomena of sex-limited inheritance and showed illustrations from the experiments of Pearl and Surface on barred and non-barred chickens.

He showed also that dominance is not a necessary factor in the production of Mendelian ratios.

The meeting was then adjourned.

Marie F. McLellan, *Secretary.*

Correction.—In the February Ohio Naturalist, p. 70, first line below "Synopsis of the Plant Phyla," read "then" instead of "through."

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THE CLASSIFICATION OF PLANTS, IX.*

JOHN H. SCHAFFNER.

Our knowledge of the gymnosperms has been greatly advanced in recent years and it is now possible to discern the broad, general lines of relationship among them with some degree of certainty. Especially important have been the contributions on the morphology of the cycads and various conifers by Chamberlain and other Chicago botainists.

In some orders, the phylogenetic relationships are still uncertain and much work remains to be done both on the cytology and on the histology of the stem. In certain genera even the gross organography is not completely known. Among the conifers, the Podocarpaeeæ and certain Taxodiaceæ greatly need serious attention.

The recent discoveries in the Pteridospermae and other fossil groups and the finding of multiciliate, motile sperms in the living Cycadophyta have definitely related the Gymnosperms to the Ptenophyte phylum; and, although one would hardly look to any known living Gymnosperms as direct ancestors of the Angiosperms, yet it seems certain that the Angiosperms and the various groups of Gymnosperms must have had rather closely related ancestors derived directly from the eusporangiate ferns. There is little probability that the real ancestry will ever be discovered, at least not until more progress is made in finding plant remains or impressions of far earlier times than any yet known. The fossil history of plants practically begins with the Cordaites, and although one may find interesting transition forms between

*Contribution from the Botanical Laboratory of Ohio State University, No. 73.

the various members of primitive seed plants in the Carboniferous and Devonian, the conclusions drawn from these sources are no more reliable or fundimental than those from living forms, except that they aid in filling up gaps which occur among those surviving to the present time.

What is needed, of course, is a series of ancestral fossils below the Devonian, leading up step by step through the successive geological formations, from a pteridophyte ancestor to the Devonian Cordiates. The speculations of those who reason from fossils of lower order which occur after the higher have appeared are of no more weight than speculations based on the present flora, which is, after all, more reliable than the extremely fragmentary material of the fossil record. It may be stated that there are, at present, no evident data in support of the direct relationship of any gymnosperm classes unless we consider the Bennettilales as a class distinct from the Cycadales. The relationship of these two groups seems to be quite certainly established. But at present most systematists would probably agree that the Cycadales and Bennettilales are closely related orders.

The strobili or cones of the Coniferæ are here regarded as true strobili and not as inflorescences, and Bessey's view that the staminate and ovulate cones are strictly homologous is maintained. When one compares the pine carpel, with its prominent ovuliferous scale, with the dwarf branch, one might easily be tempted to make them homologous; but when one goes a little further and finds the same peculiarities in the carpels of genera like Abies, where no dwarf branches exist, the conclusion has little or no weight. Much of the discussion as to the nature of the carpellate strobilus of the Pinaceæ has been based on the occurrence of occasional abnormal structures, but one can find abnormal cones that argue for the view that the carpellate cones are true strobili and not inflorescences, just as well as one can find structures that would indicate the opposite. For example, Fischer has described an abnormal cone of Pinus laricio, the lower part of which had normal stamens and the outer end of the same axis had carpels of the usual type. This bisporangiate cone was in the position of a staminate cone beside a normal staminate cone. The carpels had the usual carpellate bract and ovuliferous scale. I regard the ovuliferous scale as a peculiar structure not homologous to either stem or leaf. The fleshy structures in the Taxales must be of a similar nature. The aril of Taxus, for example, is either homologous or analogous to the ovuliferous scales of Abies and Picea.

The structure with the two ovules in Ginkgo is regarded as a megasporophyll, the whole cluster at the tip of the dwarf branch being simply a cluster of carpels. The same interpretation must then, of course, also be given to the staminate structures. The

stalk with its numerous anthers being a compound microsporophyll homologous to those of the Bennitales and the cycads. On the other hand, the sporebearing structures of the Gneteae are regarded as highly specialized strobili, the whole cluster being an inflorescence. If these views are correct, we have in a general way the same evolutionary developments in the gymnosperms as are so evident in the angiosperms. There are, however, no great number of transition types as we have in the angiosperms, where one can follow through from the primitive strobilus-like flower to a highly reduced and specialized inflorescence, with numerous vestiges, pointing out the probable course of evolution.

The arguments usually advanced from the presence of abnormalities, as stated above, are far from convincing. The change of one organ to another, or the appearance of a structure peculiar to one organ on another, simply mean that the hereditary factors have become active in a tissue where they are normally inactive or latent. One would certainly not claim that when the stamen of a rose or other flower is transformed into a petal there is a revision to a primitive condition. For this would give us a primitive flower composed entirely of petals. It is evident however, that the evolution of the rose and all other similar flowers must have proceeded in the opposite direction. Instead of a reversion we have in such cases only the expression of resident factors in structures where we do not expect them to be operative. The petal factors are present, potentially, in every cell of the entire plant body.

Because a petiole under an abnormal stimulus, caused by certain bacteria or by special manipulation, may develop stem structures is no evidence that the petiole was phylogentically ever a stem. If one finds stem-like tissues in the carpel petiole of Ginkgo, there is no unquestionable evidence that the organ was phylogenetically a stem. The stem structure may have developed as a response to the parasitism of the gametophyte and its embryo. It is also true that in the great majority of supposed phylogenetic reversions, there are after all no hereditary characters shown in the abnormal structure but what appear in the normal ontogeny. Usually there is simply an abnormal distribution in the expression of such characters. If a root under an unusual manipulation can give rise to tissues which produce flowers, this does not mean that in its past phylogeny the root was a petaliferous organ. Yet such interpretations are continually made by some biologists to account for any abnormal developments which may be shown in the various tissues of organisms.

One could certainly reconstruct a remarkably fantastic ancestral group of angiosperms or gymnosperms, were one to give weight to the multitude of monstrosities continually appearing in both vegetative and reproductive parts.

With the foregoing views as a basis for our reasoning on the phylogemy of the gymnosperms, we may regard the hypothetical relationships of the various classes and other groups as follows:

The Pteridospermae were a class of fern-like seed plants, derived from a heterosporous ptenophyte group, not yet discovered, leading off from some primitive eusporangiate, homosporous type long before Devonian times. These homosporous ferns must have had characters somewhat like our living Marattiales.

The Cycadeae are a more highly specialized branch, derived from the same primitive stock as the Pteridospermae. The Strobilophyta must also have been derived from the ancestral type which gave rise to the Cycadeae and Cordaiteae, but did not originate directly from either group. There is no satisfactory evidence that the Coniferae came from the Cordaiteae, but the two groups may have had a common ancestry segregated from some primitive Pteridosperm stock.

The Ginkgoeae seem to connect directly with the Cordaitales, but the latter are still too imperfectly known to make a comparison certain. As to the origin of the Geneteae, there is little evidence They must have been segregated in very ancient times from the early Strobilophyta, probably before the various groups composing the phylum had received their present distinguishing characters. They may have been segregated from the Strobilophyte phylum soon after the Anthophyta had been segregated from the same primitive stock as the typical Strobilophyta.

The Anthophyte phylum must have been separated long before it had advanced to its present unique morphology; perhaps at the very beginning of its seed bearing habit. The enlarged vessel-like tracheids of the Gneteae and other supposedly angiosperm characters must be regarded as merely analogous developments and not as indicating a direct line of ancestry for the Anthophyta.

The synopsis of the living Gymnospermae follows below, being carried out as far as the ordinarily recognized genera. Some of the families, as for instance the Pinaceae, present a very striking series of progressive developments and specializations. This is shown in the specialization of the leaves, dwarf branches, ovuliferous scales, carpellate bracts and other structures.

Beginning with such forms as Araucaria imbricata, as approaching the more primitive organography, and then passing through the Pinaceae, one finds a progressive tendency which finds its highest expression in Pinus. In the genus Pinus one can again find a considerable range of advancement. In Araucaria imbricata there is but one type of leaves and one type of branch; in Pinus there are four kinds of leaves and two kinds of branches and the dwarf branches are specialized to the extreme limit. The

earpel also shows successive degrees of specialization. The cones and ovuliferous scales of the white pines show an intermediate type of development between those of the spruce and Douglas-fir on the one hand and the more specialized two-leaved pines on the other.

By some, relationships and phylogenies are interpreted mainly through supposed similarities of the vascular structures. Such classifications are, however, vain unless they are supported by the combined evidence of all other structures, at least until it can be shown that the extremely hypothetical assumptions used as a basis for interpretation can be established with some degree of probability. There are no primitive vascular plants known, as indicated above, which might be used as a basis of comparison. The fossil record is a blank for any plants which would lead us to the beginning of vascular evolution and the lowest living Homosporous Pterdophytes show a considerable diversity. The living homosporous classes are about on a general level of evolutionary development and the assumption that the protostele or any other type of vascular structure is the most primitive remains to be proven. There is also no evidence that the vascular system or any other stem structure is less subject to modification than are leaf, root or reproductive structures, none of which have escaped changes of a profound nature. The assumptions based on the embryogeny of the vascular structures are no more certain than those based on the embryogeny of the reproductive parts. Nevertheless, the careful study of the vascular systems will give us another important aid in deciphering the true relationships of the higher plants, provided that the knowledge gained is correlated with evidence from other lines of investigation. It is, no doubt, permissable to call supposed embryonic recapitulations to our aid in attempting to reconstruct the hazy course of phylogenetic history, but it must be regarded as only one of the lines of evidence to be considered along with every other clue one may obtain from every structure, function, and peculiarity of the plant in its entire life cycle.

Synopsis of the Cycadophyta.

I. Leaves compound; stem an unbranched shaft or with few branches.
   1. Megasporophylls only slightly differentiated from the foliage leaves; leaves fernlike, often very much compounded; no cones formed. (Fossil). Pteridospermæ.
   2. Megasporophylls highly specialized, usually very different in form from the foliage leaves; in Cycas still showing some foliage characteristics; leaves pinnate, rarely bipinnate; at least one kind of sporophylls in cones. Cycadeæ.
      a. Microsporophylls leaflike; flowers probably all bisporangiate. (Fossil). **BENNETTITALES.**
      b. Microsporophylls not leaflike, arranged in compact monosporangiate cones; diecious. **CYCADALES.**

II. Leaves simple or merely lobed, venation dichotomous or parallel; stems with numerous branches forming a dense crown.
   1. Without dwarf branches; leaves usually elongated, with parallel veins. (Fossil.) CORDAITEÆ **CORDAITALES.**
   2. With thick wart-like dwarf branches; leaves fan-shaped, entire or lobed, sometimes deeply divided, deciduous.
   GINKGOEÆ. **GINKGOALES.** GINKGOACEÆ. **Ginkgo.** Maiden-hair-tree.

SYNOPSIS OF THE CYCADALES.

I. Megasporophylls (carpels) leaf-like, arranged in a rosette through which the main stem continues its growth; seeds 8—4, seldom 2, horizontal or erect; leaflets with a midrib; cortical cauline vascular bundles present. CYCADACEÆ. **Cycas.**

II. Megasporophylls (carpels) highly specialized, arranged in lateral cones; seeds 2, inverted; pinnæ parallel-or feather-veined. ZAMIACEÆ.
   1. Cortical cauline vascular bundles present, forming several wood zones. MACROZAMIATÆ.
      (1). Leaves simply pinnate.
         a. Carpels pointed. **Macrozamia.**
         b. Carpels shield-shaped. **Encephalartos.**
      (2). Leaves doubly pinnate; stem subterranean. **Bowenia.**
   2. Cortical bundles absent; primary cambium persistent. ZAMIATÆ.
      (1). Leaflets feather-veined. **Stangeria.**
      (2). Leaflets parallel-veined.
         a. Ovules on a process of the carpel; carpel pointed and leaf-like. **Dioon.**
         b. Ovules sessile; carpels shield-like.
            (a). Carpels shield-like, not horned.
               ((a)). Tree-like when mature; carpellate cones 2–3 ft. long. **Microzamia.**
               ((b)). Usually with a low tuberous stem or geophilous; carpellate cones much smaller. **Zamia**
            (b). Carpels 2-horned. **Ceratozamia.**

SYNOPSIS OF THE STROBILOPHYTA.

I. No vessels (enlarged tracheids) in the secondary wood; wood frequently with resin ducts; cotyledons 2–15. CONIFERÆ.
   1. Carpels usually numerous, in strobili (cones); seeds covered by the carpel tips or by ovuliferous scales; cones rarely becoming fleshy when mature; seeds dry, the testa woody or leathery. **PINALES.**
      (1). Leaves spirally arranged.
         a. Pollen wingless; carpels with one to several seeds; ovuliferous scale not prominent, or none.
            (a). Carpel with one seed; microsporangia 5–8, free and pendulous. ARAUCARIACEÆ.
            (b). Carpel with two to nine seeds; microsporangia 2–5. TAXODIACEÆ.
         b. Pollen grains winged; carpels with two inverted seeds; ovuliferous scales prominent; plants monecious. PINACEÆ.
      (2). Leaves opposite or whorled. JUNIPERACEÆ.
   2. Carpels of the cone few or 1; seeds with fleshy testa or covered by a fleshy aril. **TAXALES.**
      (1). Stamens with 2 microsporangia; pollen winged; seed 1.
         a. Not with phylloclades. PODOCARPACEÆ.
         b. With phylloclades. PHYLLOCLADACEÆ. **Phyllocladus.**
      (2). Stamens with 3–8 microsporangia, seeds 1 or 2, erect, pollen wingless. TAXACEÆ.

II. Vessels present in the secondary wood; wood without resin ducts; embryo with 2 cotyledons; strobili in specialized inflorescences; leaves opposite. GNETEÆ.

1. Archegonia well developed; primary cambium persistent; leaves scale-like; stem green and fluted. **EPHEDRALES.** EPHEDRACEÆ. **Ephedra.**

2. Archegonia reduced; concentric cortical series of vascular bundles produced; leaves ribbon-like or broad. **GNETALES.**

a. Leaves only 2, ribbon-like and split when old; stem tuberous. TUMBOACEÆ. **Tumboa** (Welwitschia).

b. Leaves numerous, broad, netted-veined. GNETACEÆ. **Gnetum.**

Synopsis of the Families of Coniferæ With More Than One Genus.

ARAUCARIACEÆ.

1. Seed without a wing, coalesced with the carpel. **Araucaria.**
2. Seed winged, free from the carpel. **Agathis.**

TAXODIACEÆ.

I. Dwarf branches; if any, and the leaves not all deciduous at the same time.

1. Not with true dwarf branches.

(1). Ovules or seeds 3; carpellate cones often clustered at the end of the twig; leaves rather broad. **Cunninghamia.**

(2). Ovules or seeds, 2, or more than 3, if 3 then the carpellate bract toothed; leaves rather narrow or scale-like.

a. Microsporangia on the stamen 3–6.

(a). Carpellate bract not toothed.

((a)). Seeds 2; carpellate cones ½ in. long. **Taiwania.**

((b)). Seeds 4–9; carpellate cones 1 in. or more in length. **Sequoia.**

(b). Carpellate bract toothed; seeds 3–6. **Cryptomeria.**

b. Microsporangia on the stamen 2; carpel with 4–9, mostly 5 seeds. **Arthrotaxis.**

2. Dwarf branches extending into a long double needle; microsporangia 2, seeds about 7. **Sciadopytis.**

II. Dwarf branches deciduous; carpel shield-like, ovules 2.

1. Ripe carpels persistent. **Taxodium.** Bald-cypress.
2. Ripe carpels deciduous. **Glyptostrobus.**

PINACEÆ.

I. Without dwarf branches.

1. With sterigmata; carpels persistent.

(1). Carpellate bracts longer than the ovuliferous scales; leaves flat. **Pseudotsuga.** Douglas-fir.

(2). Carpellate bracts shorter than the ovuliferous scales.

a. Leaves prismatic, carpellate cones drooping. **Picea.** Spruce.

b. Leaves flat.

(a). Carpellate cones drooping. **Tsuga.** Hemlock.

(b). Carpellate cones erect. **Keteleeria.**

2. Without sterigmata, carpels deciduous; carpellate cones erect; carpellate bract longer than the ovuliferous scale; leaves mostly flat. **Abies.** Fir.

II. With dwarf branches.
- 1. Dwarf branches persistent; leaves numerous, ordinary branches also with leaves.
  - (1). Leaves evergreen. **Cedrus.** Cedar.
  - (2). Leaves deciduous each year.
    - a. Carpels persistent. **Larix.** Larch.
    - b. Carpels deciduous. **Pseudolarix.** False Larch.
- 2. Dwarf branches deciduous (self-pruned); leaves few; ordinary branches with scale leaves only. **Pinus** Pine.

JUNIPERACEÆ.

- 1. Cones woody, at the ends of ordinary leafy branches. CUPRESSATÆ.
  - (1). Carpels imbricate, not shield-shaped.
    - a. Carpels with 4–5 seeds. **Thujopsis.**
    - b. Carpels with 1–3 (usually 2) seeds.
      - (a). Carpels 6–8, the four upper fertile. **Thuja.** Arborvitæ.
      - (b). Carpels 4–6, the two upper fertile. **Libocedrus.**
  - (2). Carpels valvate, not shield-shaped.
    - a. Carpellate cones with numerous sterile bracts at the base. **Actinostrobus.**
    - b. Carpellate cones with the upper set of carpels seed-bearing, the lower sterile. **Fitzroya.**
    - c. Carpellate cones with 4 carpels, without sterile bracts at the base. **Callitris** (including Widdringtonia).
  - (3). Carpels shield-shaped.
    - a. Carpels with several seeds. **Cupressus.** Cypress.
    - b. Carpels with 2 seeds. **Chamæcyparis.** White-cedar.
- 2. Cones fleshy when mature, at the ends of short or axillary branches. JUNIPERATÆ. **Juniperus.** Juniper.

PODOCARPACEÆ.

- 1. Seed more or less inverted, at least in the incipient stage.
  - (1). Both stamens and carpels in definite cones.
    - a. Leaves flat, needle-shaped; carpels spirally arranged; monecious. **Saxegothæa.**
    - b. Leaves opposite, scale-like appressed; carpels in whorls of 4; diecious. **Microcachrys.**
  - (2). Carpels 1 or few, not in a definite cone.
    - a. Seed completely inverted, all the parts of the carpel grown together. **Podocarpus.**
    - b. Seed only partly inverted, outer bract of the carpel not united with the seed. **Dacrydium.**
- 2. Seed erect; leaves scale-like; shrubs. **Pherosphæra.**

TAXACEÆ.

- 1. Carpel with 2 ovules. **Cephalotaxus.**
- 2. Carpel reduced, ovule 1.
  - a. Carpellate flowers two together; seed closely invested by the outer fleshy layer; matured female gametophyte grooved. **Torreya.**
  - b. Carpellate flowers usually solitary; seed surrounded by a free aril; matured female gametophyte even. **Taxus.** Yew.

LILIALES OF OHIO.

Blanche McAvoy.

In this study it has been my aim to arrange the species belonging to the Liliales of Ohio in a phyletic series and to make such keys as are needed for the easy identification of those species known to accur within the limits of the state. The distribution given is based on specimens in the state herbarium at the Ohio State University. It is known that this distribution is not complete, but it was thought best to confine the list to specimens at hand in order that it may be readily verified and that botanists of the state may be able to see what is needed to make the herbarium more complete.

LILIIFLORAE.

Herbs, sometimes shrubs, lianas or trees, usually with prominent flowers, having showy petals or staminodes; flowers hypogynous or epigynous, solitary or clustered, pentacyclic, trimerous, usually bisporangiate, actinomorphic in the lower forms, but zygomorphic in the higher; carpels 3 or rarely 2, united.

LILIALES.

Herbs, shrubs, lianas or trees, usually with showy flowers; flowers hypogynous, usually pentacyclic, mostly actinomorphic; bisporangiate, monecious or diecious; endosperm mealy, horny or fleshy.

Key to the Families.

1. Perianth not chaff-like and the flowers not in dense scaly heads; at least the inner whorl of the perianth petal-like; perianth segments sometimes united. 2.
1. Perianth glumaceous; or partly glumaceous with the flowers in dense scaly heads or spikes. 5.
2. Flowers usually bisporangiate; if monosporangeate then not with tendrils and flowers not in umbels. 3.
2. Flowers monosporangiate, umbellate; plants usually with tendrils, often woody. *Smilaceæ.*
3. Perianth of similar, mostly colored, persistent segments are of 3 green sepals and 3 colored, withering persistent petals; (rarely a 4-parted perianth). *Liliaceæ.*
3. Perianth ephemeral, with 3 colored, deliquescent petals or a six-parted tubular, ephemeral perianth. 4.
4. Perianth tubular, six-parted; aquatic herbs. *Pontederiaceæ.*
4. Perianth usually of 3 green sepals and 3 colored, deliquescent petals; terrestrial herbs. *Commelinaceæ.*
5. Inflorescence paniculate or capitate, always with leaf-like bracts at the base; perianth of similar segments. *Juncaceæ.*
5. Inflorescence in dense heads or spikes, without leaf-like bracts at the base. 6.
6. Ovulary unilocular; flowers bisporangiate. *Xyridaceæ.*
6. Ovulary 2-3-locular; flowers monosporangiate. *Eriocaulaceæ.*

Liliaceae. Lily Family.

Herbs, rush-like herbs, woody plants; terrestrial, usually with prominent flowers, solitary or clustered, flowers hypogynous, mostly actinomorphic; perianth segments all colored alike or differentiated into a green calyx and colored corolla; fruit a loculicidal or septicidal capsule or a berry.

Sub-families.

1. Stem erect, occasionally short, rarely with a rhizome, never with a bulb; anthers introrse; fruit a capsule or berry; flowers bisporangiate or monosporangiate. *Dracænatæ.*
1. Stems with rhizomes, corms or bulbs. 2.
2. Fruit a capsule. 3.
2. Fruit a fleshy berry, imperfect in Trillium; flowers bisporangiate. *Convallariatæ.*
3. Capsule usually loculicidal; plants mostly bulbous; flowers bisporangiate; anthers mostly introrse. *Liliatæ.*
3. Capsule mostly septicidal; plants rarely bulbous; bisporangiate, imperfectly bisporangiate, imperfectly monecious, monecious, or diecious; anthers mostly extrorse. *Melanthatæ.*

Key to the Genera of Liliaceæ.

1. Leaves in 1 or 2 whorls of from 3–9 leaves, on the flowering stem; flowers single or umbellate. 2.
1. Leaves alternate or opposite or occasionally in several whorls, often basal. 3.
2. Leaves three, flowers solitary. *Trillium.* (17)
2. Leaves in two whorls; flowers in umbels. *Medeola.* (18)
3. Flowers in the axils of the leaves, either solitary or clustered. 4.
3. Flowers terminal or scapose, solitary or clustered. 7.
4. Leaves minute bracts, phylloclades needle-like. *Asparagus.* (26)
4. Leaves ordinary, not reduced to bracts. 5.
5. Flowers solitary. 6.
5. Flower clusters umbellate, consisting of 2 or more flowers. *Salomonia.* (21)
6. Leaves long-acuminate, rounded, clasping, membranous. *Streptopus.* (19)
6. Leaves oblong-lanceolate, mostly sessile or perfoliate. *Uvularia.* (10)
7. Perianth segments united. 8.
7. Perianth segments separate. 11.
8. Perianth segments 4–6 in. long; flowers bright yellow or orange. *Hemerocallis.* (4)
8. Perianth segments less than ½ in. long; flowers white, blue or pale yellow-green. 9.
9. Leaves narrow, linear, coming from a bulb; flowers blue, rarely pinkish, small, in a dense raceme. *Muscari.* (8)
9. Leaves lanceolate or broadly lanceolate. 10.
10. Scape sheathed by the bases of the 2 or 3 leaves; flowers white and sweet-smelling. *Convallaria.* (25)
10. Scape much exceeding the many radical leaves; flowers yellow or white. *Aletris.* (9)
11. Flowers single, terminal; scape with two oblong or oblong-lanceolate leaves. *Erythronium.* (3)
11. Flowers in clusters of 2 or more, or if single then the stems leafy. 12.
12. Flowers in definite umbels or 1–3 at the end of the flowering branch. 13.
12. Flowers in corymbs, panicles, racemes or spikes. 17.

13. Leaves linear, terete, or eliptic-lanceolate; if eliptic-lanceolate then flowers appearing before the leaves; odor pungent. *Allium.* (5)
13. Leaves ovate, ovate-lanceolate, or lanceolate. 14.
14. Flower stalk leafy at the base, peduncle scapose. *Clintonia.* (24)
14. Flower stalk leafy to the top. 15.
15. Anthers versatile, styles united, stigma 3-lobed. *Lilium.* (2)
15. Anthers not versatile, styles separate above the middle. 16.
16. Leaves long-acuminate, plant finely pubescent; perianth segments ¾ in. long, flowers usually in 2's, sometimes from 1–3, greenish. *Disporum.* (20)
16. Leaves acute, plants glabrous or somewhat pubescent on the under side of the leaves when young; perianth segments about 1 in. long, flowers usually single, yellow or greenish-yellow. *Uvularia.* (10)
17. Leaves not grass-like, but broad-ovate, oval or lanceolate. 18.
17. Leaves grass-like or sword-shaped, occasionally fleshy, sometimes 1 in. or more broad. 21.
18. Flower cluster a spike of staminate or carpellate flowers; diecious. *Chamælirion.* (15)
18. Flowers in simple racemes at the end of leafy branches; or if in a compound raceme then without leafy bracts. 19.
18. Flowers in a compound raceme with leafy bracts, or in a closely appressed panicle; leaves 10–14 in. long, oval to oblong. *Veratrum* (12)
19. Perianth 6-parted, stamens 6. 20.
19. Perianth 4-parted, stamens 4, plants small, leaves usually 2. *Unifolium.* (23)
20. Flowers large and showy, red, yellow or orange. *Lilium.* (2)
20. Flowers small, greenish. *Vagnera.* (22)
21. Flowers in simple racemes or corymbose. 22.
21. Flowers in branched racemes or panicles. 24.
22. Flowers involucrate with 3 bractlets; plants not bulbous. *Tofieldia.* (16)
22. Flowers not involucrate; plants bulbous. 23.
23. Flowers numerous, filaments filiform. *Quamasia.* (6)
23. Flowers usually less than 7, filaments flattened. *Ornithogalum.* (7)
24. Leaves 1 in. wide or more, pubescent or roughened. 25.
24. Leaves ½ in. or less wide, glabrous. 26.
25. Flowers large, showy, white; segments not clawed, 1–1½ long; leaves rigid or sword-shaped. *Yucca.* (1)
25. Flowers smaller, greenish-white, segments clawed; plant pubescent. *Melanthium.* (11)
26. Perianth segments acute, bearing 1 or 2 glands or a spot. *Zygadenus.* (13)
26. Perianth segments acuminate not gland-bearing. *Stenanthium.* (14)

Dracænatæ.

1. **Yucca** L. Yucca.

Stems woody, bearing evergreen, stiff, linear leaves and having a panicle of nodding, showy, white flowers. Perianth of six ovate or ovate-lanceolate segments; stamens shorter than the perianth; anthers small and versatile.

Yucca filamentosa L. Adam's-needle. Stem short; leaves evergreen and narrowed above, acuminate and sharp pointed, ¾-2 in. wide, filiferous on the margin; panicle large and densely flowered, on a scape 1-9 feet high; perianth segments 1-2 inches long; fruit an erect capsule, ¾ in. thick. Escaped in Franklin County.

Liliatæ.

2. **Lilium** L. Lily.

Tall bulbous herbs with short rhizomes and simple, leafy stems; flowers erect or drooping, showy, bisporangiate; perianth funnel form of 6 separate, spreading or recurved segments, all alike, or nearly so, nectar bearing; stamens 6, extrorse; anthers, versatile; style elongated; stigma 3 lobed; capsule loculicidal.

1. Perianth segments not clawed, flowers drooping or spreading. 2.
1. Perianth segments narrowed into long claws, flowers erect. 3.
2. Leaves smooth, perianth segments recurved. *L. superbum.*
2. Leaves roughened or tuberculate on the veins beneath; perianth segments recurved or spreading. *L. canadense.*
3. Leaves mostly whorled, lanceolate or linear lanceolate. *L. philadelphicum.*
3. Leaves, all but the uppermost, scattered, narrowly linear. *L.* umbellatum.

1. **Lilium superbum** L. Turk's-cap Lily. Stem 2-7½ feet high; leaves lanceolate, smooth, acuminate at both ends, lower leaves whorled; one-to-many-flowered, flowers drooping or spreading, orange, yellow-orange or rarely red, purple spotted, long peduncled, formimg large panicles; perianth segments recurved. In meadows and marshes. Reported for Erie County. Mosley's herbarium.

2. **Lilium canadense** L. Canada Lily. Stem 2-6 feet high; leaves remotely whorled, lanceolate, 3 nerved, roughened or tuberculate on the veins beneath; flowers drooping or spreading, long peduncled, yellow or orange, usually spotted with brown; perianth segments recurved or spreading. In swamps or meadows. General.

3. **Lilium philadelphicum** L. Philadelphia Lily. Stem 1½-3 feet high; leaves linear-lanceolate, mostly whorled; flowers 1-3, erect, reddish orange, spotted with purple inside; perianth segments narrowed into long claws. Dry or sandy soil. Fulton, Lucas, Sandusky, Erie.

4. **Lilium umbellatum** Pursh. Western Red Lily. Similar to L. philadelphicum, but more slender; leaves, all but the uppermost scattered, narrowly linear; flowers 1-3, red, orange or yellow, spotted below; erect, perianth segments narrowed into claws, shorter than the blade. In dry soil on prairies. Stark County.

3. **Erythronium** L. Dog-tooth Lily.

Nearly stemless herbs arising from a deep bulb, stem bearing two smooth, spotted leaves with sheathing petioles and one nodding flower at the top; perianth of 6 lanceolate, recurved or spreading divisions; anthers oblong-linear, style elongated; capsule obovoid, contracted near the base.

1. Flowers yellow; stigmas very short. *E. americanum.*
1. Flowers white or pinkish white; stigmas longer, spreading and more recurved. *E. albidum.*

1. **Erythronium americanum** Ker. Yellow Dog-tooth Lily. A bulbous herb with green leaves mottled with purple and white; perianth yellow; style club-shaped; stigmas 3, united. In woods and thickets. General.

2. **Erythronium albidum** Nutt. White Dog-tooth Lily. Leaves somewhat narrower than the preceding species, not so much spotted; perianth white, pinkish or bluish-pink; stigmas spreading. General.

4. **Hemerocallis** L. Day-lily.

Showy perennials with fiberous, fleshy roots, and two-ranked, linear leaves at the base of the tall scapes. Scape many flowered, each flower having a bract and remaining open but for one day; perianth funnel-form, the lobes longer than the tube; stamens united with the tube, anthers introrse, filaments long and thread-like; style long, stigma simple.

1. **Hemerocallis fulva** L. Common Day-lily. Scape 3–6 feet tall; leaves channeled; flowers 6-18, short pedicelled, tawny orange. Escaped. General.

5. **Allium** L. Onion. Leek. Garlic.

Herbs with alliaceous odor, arising from solitary or clustered bulbs. Leaves narrowly linear, or rarely lanceolate; scape simple and erect; flowers small, in umbels; perianth white, pink, purple, green; parts distinct, or united at the very base; style persistent, and thread-like; capsule lobed; seeds black.

1. Leaves oblong-lanceolate, not present at the time of flowering; capsule strongly 3-lobed. *A. tricoccum.*
1. Leaves linear or elongated, present at the time of flowering. 2.
2. Leaves hollow, terete or nearly so. 3.
2. Leaves solid. 4.
3. Stem leafy to above the middle; leaves thread-like, grooved down the upper side. *A. vineale.*
3. Stem leafy only near the base; leaves usually broad, not definitely grooved, flowers white. *A. cepa.*
4. Scape terete, not angular, umbels erect, with bulblets, ovulary not crested. *A. canadense.*
4. Scape angular, umbels nodding without bulblets, ovulary and capsule crested. *A. cernuum.*

1. **Allium tricoccum** Ait. Wild Leek. An herb with clustered ovoid bulbs and with oblong lanceolate leaves, withering before flowering time. Leaves 6–12 in. long; tapering into a long petiole; scape 4–6 in. tall; umbels bracteolate, many flowered, erect; flowers white; perianth segments oblong, of about the same length as the filaments; capsule 3-lobed. In woods. West central part of the state to Franklin and Delaware. Also in Lorain, Cuyahoga and Medina.

2. **Allium vineale** L. Field Garlic. A slender herb with a stem 1–3 feet high sheathed by the bases of the leaves below the

middle. Leaves terete and hollow, slender, channeled above; umbels many-flowered, erect, bulbiferous; flowers white; perianth segments obtuse; capsule deeply three-lobed. Franklin and Harrison.

3. **Allium cepa** L. Common Onion. Scape exceeding the leaves; bulb scaley; leaves hollow, sometimes terete, usually broader than thick; flowers white. Sometimes persistent.

4. **Allium canadense** L. Meadow Garlic. Scape 12 in. high, terete, bulb small; leaves basal or nearly so, narrowly linear, slightly convex beneath; umbels bulbiferous; flowers pink or white; perianth segments narrowly lanceolate. General.

5. **Allium cernuum** Roth. Nodding Onion. Bulbs narrowed into a neck; leaves linear, flattened and slightly keeled, 1 ft. long; scape slightly ridged, 1–2 feet tall, bearing a loose or drooping few-to-many-flowered umbel; flowers rose-colored, to purple; capsule 6-crested. General.

6. **Quamasia** Raf. Wild Hyacinth.

Bulbous herbs with linear leaves and a terminal inflorescence of rather large, blue, purple or white flowers. Perianth slightly irregular of 6 blue or purple, spreading 3 to 7 nerved segments; stamens united with the bases of the segments; anthers versatile, introrse; capsule oval.

1. **Quamasia hyacinthina** (Raf.) Britt. Wild Hyacinth. Scape 6–28 in. tall; leaves keeled; raceme elongated; bracts longer than the pedicels; flowers pale blue; 3 nerved. General, but rare in eastern Ohio.

7. **Ornithogalum** L. Star-of-Bethlehem.

Bulbous herbs with narrow, basal, fleshy leaves. Inflorescence in a terminal, bracted, corymb or raceme of white, yellowish or greenish flowers; anthers introrse and versatile; stigma three lobed or three ridged.

Ornithogalum umbellatum L. Star-of-Bethlehem. Bulbs ovoid, tufted; scape slender, 4–12 in. high; leaves narrow, dark green with lighter mid-rib; flowers in a simple raceme or corymb, erect or ascending; perianth segments white above and green and white below; stamens ½ the length of the segments. Escaped from gardens. Montgomery, Miami, Gallia, Franklin and Auglaize.

8. **Muscari** Mill. Grape-hyacinth.

Low bulbous herbs, with basal, linear, fleshy leaves and small, usually blue (rarely pink or white) flowers, in a dense raceme. Perianth globular of united segments; stamens included; anthers introrse; style short.

1. **Muscari botryoides** (L.) Mill. Grape-hyacinth. Leaves linear, erect; flowers deep blue, pedicels shorter than the flowers. Montgomery, Lake.

9. **Aletris** L. Colic-root.

Perennial, smooth, stemless herbs, fibrous rooted with basal lanceolate leaves. Inflorescence a spike-like raceme; flowers small, bracted, white or yellow; perianth campanulate of six united, persistent segments; stamens united with the perianth; stigmas minutely 2-lobed; capsule ovoid.

Aletris farinosa L. Colic root. Scape 16–36 in. tall, slender, terete; basal leaves lanceolate or linear-lanceolate, acuminate at the tip, narrowed at the base, pale in color, 2–6 in. long; raceme 4–12 in. long or somewhat longer; flowers white or yellowish; style subulate; capsule ovoid, loculicidal above. Counties along Lake Erie.

Melanthatæ.

10. **Uvularia** L. Bellwort.

An erect, perennial herb from a root-stock. Stem leafy above and scale-bearing below; leaves alternate, perfoliate or sessile; flowers peduncled, drooping, solitary or occasionally in two's at the end of the branches; perianth narrow or bell-shaped; stamens 6, free, or united to the base of the perianth segments; anthers linear; capsule ovoid or obovoid, three angled.

1. Leaves sessile, not perfoliate. *U. sessilifolia.*
1. Leaves perfoliate. 2.
2. Perianth segments pubescent within, stamens shorter than the style, plants glaucous, leaves glabrous. *U. perfoliata.*
2. Perianth segments smooth within or nearly so, stamens longer than the style, plants not glaucous, leaves pubescent beneath. *U. grandiflora.*

1. **Uvularia sessilifolia** L. Sessile-leaf Bellwort. Glabrous herb with a slender stem and but one or two leaves below the fork. Leaves oblong or oblong-lanceolate, 1–5 in. long, thin, sessile, acute at each end, margins slightly rough, pale or glaucous beneath, flowers greenish yellow; perianth segments smooth; styles exceeding the stamens; anthers blunt; capsule narrowed at both ends, 1 in. long. Lucas, Cuyahoga, Summit, Mahoning, Gallia.

2. **Uvularia grandiflora** Sm. Large-flowered Bellwort. Stem stout, yellowish-green, not glaucous, naked or bearing 1 or 2 leaves below the fork; leaves perfoliate, oblong, oval or ovate, somewhat acuminate, whitish-pubescent beneath; perianth segments smooth within or nearly so; stamens exceeding the styles; capsule obtusely lobed. General

3. **Uvularia perfoliata** L. Perfoliate Bellwort. A slender plant 6–20 in. high, with 1–3 leaves below the fork. Leaves glaucous, oblong to ovate-lanceolate, acute; perianth segments pale yellow, pubescent within; stamens shorter then the style or equaling them; capsule obovoid, truncate, 3-angled with concave sides and grooved ridges. General.

11. **Melanthium** L. Bunch-flower.

Tall leafy, pubescent herbs, perennial from short root stocks. Leaves oval, lanceolate or linear; inflorescence a pyramidal panicle; flowers greenish, white or cream colored; perianth of spreading segments, clawed, filaments shorter than the divisions of the perianth, somewhat united to the perianth segments; anthers cordate or reniform; styles 3, subulate.

1. **Melanthium virginicum** L. Virginia Bunch-flower. Stem 1½–5 feet tall, rather slender; leaves linear, ½–1½ in. wide; divisions of the perianth ovate to oblong, clawed, the claw about one-third of the whole length of the segment. Richland, Wayne.

12. **Veratrum** L. False-hellebore.

Tall perennial herbs with short, poisonous rootstocks. Leaves broad and for the most part clasping; stem and inflorescence somewhat pubescent; inflorescence a terminal panicle or spike-like raceme; flowers greenish, yellowish or purple, bisporangiate or monecious on short pedicels; stamens free short and recurved.

1. Stem stout and very leafy toward the top, inflorescence spreading in a dense spike-like raceme, ovulary glabrous. *V. viride.*
1. Stem slender, leaves few, inflorescence in a narrow panicle, ovulary tomentose. *V. woodii.*

1. **Veratrum woodii** Robb. Wood's False-hellebore. Stem slender, sparingly leafy, 1–5 feet high; leaves oblanceolate, only the lowest clasping; panicle narrow; perianth greenish-purple, with entire segments; ovulary tomentose; capsule few-seeded. Auglaize county.

2. **Veratrum viride** Ait. American False-hellebore. Stem stout, very leafy at the top, 2–7 feet tall; leaves broadly oval, pointed; sheath clasping; inflorescence a dense, spreading spike-like raceme; perianth yellowish-green; segments twice as long as the stamens, ciliate serrulate; ovulary glabrous; capsule many-seeded. Ashtabula county.

13. **Zygadenus** Mx. Zygadene.

Erect perennial bulbous, glabrous herbs with rather large panicled, greenish-white flowers. Stems leafy; leaves linear; perianth segments separate or united below; stamens free from the perianth segments.

1. **Zygadenus elegans** Pursh. Glaucous zygadenus. Very glaucous, stem slender, ½–3 feet tall; leaves keeled; inflorescence sometimes one foot long; flowers greenish; perianth segments oval to obovate, obtuse, somewhat united. Champaign, Stark, Highland, Ottawa.

14. **Stenanthium** Kunth.

Erect, glabrous, bulbous, perennial herbs, with long grass-like, keeled leaves. Inflorescence of numerous small flowers, forming a long terminal panicle; perianth segments oblong or ovate, spreading; stamens somewhat shorter than the perianth; filaments subulate; anthers oblong.

1. **Stenanthium robustum** Wats. Stout Stenanthium. Stem stout, usually leafy, 3–5 ft. tall, leaves 1 ft. or more long; panicle dense, usually compound; flowers greenish or white; capsule ovoid-oblong, erect, with a short recurved beak. Fairfield.

15. **Chamaelirium** Willd.

Smooth herbs with erect stems, from bitter, tuberous, root-stocks bearing a spike like raceme of small, white, bractless flowers, dioecious; carpellate plant more leafy than the staminate; leaves flat, lanceolate or oblanceolate, tapering into a petiole; perianth of 6, 1-nerved segments; carpellate flower with vestigial stamens.

1. **Chamaelirium luteum** (L.) Gr. Chamaelirium. Stem 1–4 feet high, the carpellate plant usually higher; basal leaves 2–8 in. long; capsule oblong. Sandusky, Erie, Cuyahoga, Summit, Medina, Wayne, Licking, Lawrence.

16. **Tofieldia** Huds.

Perennial herbs with short, erect or horizontal rootstocks, fiberous roots, and slender, erect, almost leafless stems. Leaves linear and clustered at the base; flowers bisporangiate in a terminal raceme, or rarely solitary, white or green; pedicels bracted; perianth segments oblong or obovate, persistent; stamens 6; anthers introrse; ovulary sessile, styles 3, recurved.

1. **Tofieldia glutinosa** (Mx.) Pers. Glutinous Tofieldia. Stem vicid, pubescent, 6–20 in. tall with 2–4 basal leaves; inflorescence a short raceme, three-eighths to one and one-fourth in. long, bearing small involucral bracts; flowers very small; perianth segments oblong or obtuse; capsule oblong. Stark, Champaign.

Convallariatæ.

17. **Trillium** L.

Glabrous, erect, unbranched herbs, from short, root-stocks, with a whorl of 3 leaves at the summit of the stem. Perianth of 3 green, persistent sepals and 3 withering or deciduous, colored petals, ovulary 3 or 6 angled.

1. Flowers peduncled. 2.
1. Flowers sessile. 6.
2. Leaves sessile or subsessile. 3.
2. Leaves petioled; oval or ovate. 5.

3. Petals obovate or oblanceolate, white or pinkish, sometimes darker with age. *T. grandiflorum.* (1)
3. Petals ovate or lanceolate. 4.
4. Peduncles 1–4 in. long, erect or declined; petals spreading, flowers ill-scented; dark purple, pink or white. *T. erectum.* (2)
4. Peduncles usually less than 1 in. long, recurved beneath the leaves, petals recurved, white or pink. *T. cernuum.* (3)
5. Leaves acuminate, about 6 in. long; flowers pure white. *T. undulatum.* (4)
5. Leaves oval, obtuse or merely acute, small, flowers white with purple stripes at the bases. *T. nivale.* (5)
6. Leaves sessile, sepals erect or spreading. *T. sessile.* (6)
6. Leaves petioled, sepals reflexed. *T. recurvatum.* (7)

1. **Trillium grandiflorum** (Mx,) Salisb. Large-flowered Trillium. Leaves peduncled, somewhat rhombic-ovate; petals oblanceolate or obovate, white or pinkish, sometimes darker with age; stamens with stout filaments and usually exceeding the slender stigmas. General.

2. **Trillium erectum** L. Ill-scented Trillium. Leaves broadly rhombic, short acuminate; petals ovate or lanceolate, white, pink or deep purple; stamens exceeding the stout recurved stigmas; flowers ill-scented. General.

3. **Trillium cernuum** L. Nodding Trillium. Leaves broadly rhombic ovate; peduncle usually less than one in. long and recurved beneath the leaves; petals recurved, white or pinkish; filaments about equalling the anthers; stigma stout at the base, but tapering toward the apex. Auglaize, Champaign, Medina.

4. **Trillium undulatum** Willd. Painted Trillium. Leaves ovate and taper-pointed; petals ovate or oval-lanceolate, pointed and wavy, white with purple stripes. Ashtabula county.

5. **Trillium nivale** Ridd. Early Trillium. Small, 2–4 in. high. Leaves oval or ovate, obtuse; petals oblong, obtuse, white, scarcely wavy; styles long and slender. Miami, Clark, Greene, Franklin.

6. **Trillium sessile** L. Sessile Trillium. Leaves sessile and usually mottled; flowers sessile; sepals spreading or erect, narrowly lanceolate or oblanceolate, dark and dull purple, varying to greenish. General.

7. **Trillium recurvatum** Beck. Prairie Trillium. Leaves petioled and somewhat mottled, ovate, oblong or obovate; flowers sessile; sepals reflexed; petals clawed, dark purple. Auglaize, Hamilton.

18. **Medeola** L.

A slender, erect, unbranched herb, clothed with deciduous tomentum, arising from a tube-like rootstock and bearing two or three whorls of oblong-lanceolate leaves and a sessile umbel of small, recurved flowers. Perianth of 6 equal, recurved, greenish-yellow segments; stamen filaments slender; styles 3, recurved.

1. **Medeola virginiana** L. Indian Cucumber-root. 1–2½ feet high; the lower whorl of leaves sessile, acuminate, narrowed at the base, 3 to 5 nerved; umbel 2-9 flowered; perianth segments obtuse; berry dark purple. General.

19. **Streptopus** Mx. Twisted Stalk.

Branching herbs with thin, sessile, or clasping, alternate leaves. Flowers solitary or in two's, greenish, rose or purplish, small and nodding; peduncles bent or twisted at about the middle; perianth campanulate of 6 spreading or recurved segments, deciduous, stamen-filaments short; style slender.

1. **Streptopus amplexifolius** (L.) DC. Clasping-leaf twisted stalk. Plant 16–36 in. high, usually branching below the middle; leaves cordate clasping at the base, glabrous; berry oval. Reported for Ohio.

20. **Disporum** Salisb.

Herbs with slender root stocks and branching stems. Leaves alternate, sessile or clasping; flowers terminal, nodding, solitary or in simple umbels, white or greenish-yellow; perianth of narrow, deciduous, segments; anthers extrorse; style slender; berry oval or ovoid.

1. **Disporum lanuginosum** (Mx.) Nich. Hairy Disporum. Pubescent herbs with ovate-lanceolate or oblong-lanceolate leaves, 2–4 in. long, long acuminate at the apex and rounded at the base. Flowers solitary, or in two's or three's, greenish, ½–¾ in. long, campanulate, glabrous, style slender; berry oval, red. In woods. Huron, Lorain, Cuyahoga, Ashtabula, Medina, Columbiana, Morrow, Perry, Richland, Wayne, Adams.

21. **Salomonia** Heist. Solomon's Seal.

Herbs with scarred root-stocks and simple aerial stems, scaly below and leafy above, the leaves sessile and alternate in ours. Flowers usually greenish, axillary, drooping, peduncled, solitary or umbellate; pedicels jointed at the base; perianth 6-lobed; stamens included, united with the perianth; styles slender; fruit a dark blue berry with a bloom.

1. Plants glabrous throughout; filaments smooth, flowers usually clustered. *S. commutata.*
1. Leaves pubescent beneath; filaments roughened, flowers usually in two's. *S. biflora.*

1. **Salomonia commutata** (R. & S.) Brit. Smooth Solomon's-seal. A glabrous herb, 1–8 ft. high. Leaves rounded and sometimes clasping at the base; peduncle 1–8 flowered, glabrous; flowers ½–¾ in. long. In moist woods and along streams. General.

2. **Salomonia biflora** (Walt.) Britt. Hairy Solomon's-seal. A slender herb 8 in.–3 ft. high with glabrous stem. Leaves acute or acuminate at the apex, often obtuse at the base, pubescent (especially on the veins) beneath, glabrous above; peduncles commonly 2-flowered, sometimes 1–4 flowered; flowers ¼–½ inch long. In woods and thickets. General.

22. **Vagnera** Adans. False Solomon's Seal.

Herbs with stems scaly below and leafy above. Leaves alternate, short petioled or sessile; inflorescence a terminal raceme or panicle; flowers small, white or greenish; stamens united with the base of the segments; anthers introrse; fruit a globular berry; seeds 1 or 2.

1. Flowers numerous and panicled. *V. racemosa.*
1. Flowers few and racemose. 2.
2. Leaves numerous. *V. stellata.*
2. Leaves 2–4. *V. trifolia.*

1. **Vagnera racemosa** (L.) Mor. Panicled False Solomon's-seal. Herbs with fleshy root-stocks and angled, leafy stems 1–3 ft. high. Leaves oblong-lanceolate, or oval, sessile or short-petioled, 2¾–6 in. long, acuminate, finely pubescent beneath, margins ciliate; panicle dense, peduncled; perianth segments oblong; fruit an aromatic red berry speckeled with purple. In moist woods and thickets. General.

2. **Vagnera stellata** (L.) Mor. Stellate False Solomon's-seal. A leafy herb 8–20 in. high with a stout fleshy rootstock. Stems glabrous; leaves oblong-lanceolate or lanceolate, sessile or clasping, minutely pubescent beneath; inflorescence a raceme ¾-2 in. long, several-flowered; berry reddish or green striped with black. In moist soil. General.

3. **Vagnera trifolia** (L.) Mor. Three-leaf False Solomon's-seal. A glabrous herb with slender root-stocks usually with 3, sometimes 2–4 leaves. Leaves oblong or oblong-lanceolate, sessile, acute or acuminate at the apex, narrowed at the base; inflorescence a few flowered panicled raceme, perianth segments obtuse or somewhat reflexed; berry dark red. In bogs and wet places. Fulton, Lorain.

23. **Unifolium** Adans. False Lily-of-the-valley.

Low herbs with slender rootstocks; simple, few-leaved stems and small white flowers in a small, terminal raceme. Perianth of separate, spreading segments; stamens 4, united with the base of the segments; ovulary sessile, 2-locular, berry 1–2 seeded.

1. **Unifolium canadense** (Desf.) Greene. False Lily-of-the-valley. Herbs 2–7 in. high with slender stems, bearing 1–3, usually 2, leaves. Leaves ovate, ovate-lanceolate or cordate,

sessile or short-petioled; raceme many-flowered; perianth segments becoming reflexed; fruit a speckled, pale-red berry. In moist woods and thickets. General.

24. Clintonia Raf.

Herbs somewhat pubescent with slender root-stocks and erect simple scapes and broad, petioled leaves. Inflorescence an umbel of bractless flowers; perianth segments equal or nearly so; stamens united with the perianth; ovulary bi-or tri-locular; fruit a globose or oval berry.

1. Umbel 3–6 flowered, perianth $\frac{1}{2}$–$\frac{3}{4}$ in. long, greenish-yellow. *C. borealis.*
1. Umbel many flowered, perianth $\frac{1}{4}$ in. long or less than $\frac{1}{2}$ in. long, white speckled. *C. umbellulata.*

1. **Clintonia borealis** (Ait.) Raf. Yellow Clintonia. Leaves oval, thin, ciliate, short-acuminate; inflorescence 3–6-flowered; stamens as long as the perianth; ovulary bilocular; berry oval. In moist woods and thickets. Ashtabula County.

2. **Clintonia umbellulata** (Mx) Torr. White Clintonia. Herbs with scape 8–18 in. high. Leaves 2–5, oblong, oblanceolate or obovate, acute or cuspidate, ciliate; inflorescence a many-flowered umbel; pedicels pubescent; flowers white, sometimes dotted with purple; ovulary 2-locular; fruit a few-seeded, globose berry. In woods. Harrison, Portage, Wayne.

25. Convallaria L. Lily-of-the-valley.

A low perennial with 1 or 2 leaves with sheathing petioles. Scape bearing a one sided raceme of white, rarely pinkish, fragrant, nodding flowers, perianth of 6 united segments; stamens united with the perianth; filaments short, anthers introrse; fruit a berry.

1. **Convallaria majalis** L. Lily-of-the-valley. Scape 4-10 in. high, shorter than the leaves and scaly near the base. Escaped from cultivation in Franklin County.

26. Asparagus L. Asparagus.

Stem at first simple, fleshy, scaly and at length becoming much branched and bearing phylloclades, the whole having a plume-like appearance. Flowers small, solitary, umbelled or racemed; perianth segments alike, separate or slightly united at the base; anthers introrse; ovulary sessile, trilocular; styles short; berry globose.

1. **Asparagus officinalis** L. Asparagus. Young stems thick and edible, but later developing into a plume-like branch. Rootstocks much branched; leaves reduced to scales and branchlets reduced to phylloclades; flowers mostly solitary and drooping at the nodes; perianth campanulate; berry red. Escaped from cultivation along road-sides, salt marshes and fields. General.

SMILACEAE. Smilax Family.

Mostly vines with woody or herbaceous often prickly stems. Leaves alternate, netted-veined, several nerved, petioled; petioles sheathing, bearing tendrils, persistent after the fall of the leaf; flowers small, greenish, diecious, in umbels in the axils of the leaves; perianth of 6 segments; stamens 6; ovulary trilocular; style short or none; fruit a berry; seeds 1–6 with much endosperm; embryo small.

Smilax L. Smilax.

Usually twining or climbing herbs with tendrils from the petioles. Lower leaves reduced to scales; flowers actinomorphic; perianth segments distinct, deciduous, the carpellate flowers with vestigial stamens; berry black, red or purple or rarely white.

1. Aerial stems herbaceous, dying down each year, flowers carrion-scented, berries blue-black with a bloom. 2.
1. Aerial stem woody, often prickly. 4.
2. Plants erect, mostly without tendrils. *S. ecirrhata.*
2. Plants, with tendrils, climbing, without prickles. 3.
3. Leaves smooth on both sides, peduncles very long. *S. herbacea.*
3. Leaves sparingly to densely puberulent on the veins beneath. *S. pulverulenta.*
4. Leaves green, not glaucous. 5.
4. Leaves very glaucous; peduncles, ½–1 in. long, usually not much longer than the petioles. *S. glauca.*
5. Peduncle about 2 in. long, leaves usually 7–9 nerved. *S. pseudo-china.*
5. Peduncle 1–1½ in. long, leaves usually 7-nerved. *S. hispida.*
5. Peduncle usually less than ½ in. long, about as long as the petiole, leaves usually 5-nerved. *S. rotundifolia.*

1. **Smilax ecirrhata** (Engl.) Wats. Upright Smilax. A glabrous, erect herb with the leaves often whorled at the top. Leaves ovate, rounded or cordate at the base, 5–9 nerved, somewhat pubescent beneath. In dry soil. Erie, Wood, Preble, Warren, Clinton, Brown, Fairfield, Hardin.

2. **Smilax herbacea** L. Common Carrion-flower. An unarmed, glabrous herb more or less climbing. Leaves ovate, rounded or lanceolate, acute or acuminate at the apex, obtuse or cordate at the base, 7–9-nerved; peduncles 6–10 times as long as the petiole, flattened, inflorescence a many-flowered umbel; flowers carrion-scented; fruit a blue-black berry. In woods or thickets. General.

3. **Smilax pulverulenta** Mx. Pubescent Carrion-flower. Similar to the preceding except that the undersides of the leaves are pubescent, especially on the veins. Williams, Fulton, Ottawa, Erie, Seneca, Cuyahoga, Hardin, Auglaize, Fayette, Montgomery.

4. **Smilax pseudo-china** L. Long-stalked Greenbrier. A glabrous climbing woody vine, commonly covered with numerous slender prickles. Branches more or less angled; petioles 1–1½ in. long; leaves ovate, abruptly acute at the apex, subcordate at the base, usually 1-nerved; with 12–40 flowers; fruit a black berry. In thickets. General.

5. **Smilax glauca** Walt. Glaucous Greenbrier. A climbing woody vine with terete stem and four-angled branches and glaucous leaves. Stem often prickly; peduncle ½–1 in. long; leaves ovate, acute or cuspidate at the apex, sometimes cordate at the base, five-nerved; umbel 6-12 flowered; fruit a blue-black berry. In dry, sandy soil. General, but more abundant in the south.

6. **Smilax rotundifolia** L. Round-leaf Greenbrier. A glabrous woody climber with a terete, woody stem and a square branch usually prickly. Petioles less than ½ in. long; leaves thick, shining when mature, acute or acuminate at the apex, obtuse or cordate at the base, entire or very slightly denticulate, 5 nerved; peduncles flattened; umbel 6-25-flowered; fruit a black berry. In woods and thickets. Cuyahoga, Belmont, Hocking, Fairfield, Licking, Lorain.

Pontederiaceae. Pickerel-weed Family.

Perennial, aquatic herbs with broad, petioled leaves or long, grass-like leaves. Flowers bisporangiate, showing some zygomorphy, solitary or spiked with a spathe; perianth of six united segments; stamens 6 or 3, united with the perianth; ovulary trilocular or unilocular; stigma terminal; fruit a many seeded capsule; endosperm of the seed copious, mealy.

1. Spike many-flowered, with a spathe-like bract, perianth two-lipped, stamens 6. *Pontederia.* (1)
1. Inflorescence one to several-flowered, perianth with a slender tube, perianth segments about equal, stamens 3. *Heteranthera.* (2)

1. **Pontederia** L. Pickerel-weed.

Herbs with thick leaves, long sheathing petioles and horizontal rootstock. Inflorescence a spike with numerous, ephemeral, blue flowers; perianth two lipped; stamens 6, united with the perianth; ovulary trilocular, 2 locules without ovules.

1. **Pontederia cordata** L. Pickerel weed. A rather stout, erect herb with ovate or cordate, sagittate leaves, with apex and basal lobes obtuse, the sheathing petiole often having long appendages; spathe and inflorescence pubescent; flowers blue, the upper lobe having two yellow spots on the middle segment. Borders of ponds and streams. Erie, Cuyahoga, Geauga, Summit, Portage, Wayne, Lucas, Fulton, Defiance, Licking, Perry.

Pontederia cordatalancifolia (Muhl.) Mor. Similar to the preceding but with lanceolate leaves, rounded or narrowed at the base. Summit County.

2. **Heteranthera** R. & P.

Aquatic herbs with creeping, ascending or floating stems with petioled cordate, ovate, oval or reniform leaves; or with grass-like leaves.

1. **Heteranthera dubia** (Jacq.) Mac. M. Water Stargrass. A slender forked herb, often rooting at the nodes. Leaves flat, elongated, acute, with thin sheathes and stipule-like appendages; spathe 1–2 flowered, flowers light yellow, stigma lobed, fruit a unilocular capsule. Growing in still water. Rather general.

Commelinaceae. Spiderwort Family.

Perennial or annual leafy herbs. Inflorescence an umbel-like cyme of bisporangiate, showy, flowers, subtended by spathe-like or leafy bracts; sepals 3, persistent; petals 3, membranous, delequescent; stamens 6, sometimes 3 of them sterile; ovulary bi- or tri-locular; capsule loculicidal; endosperm copious and mealy.

1. Bracts leaf-like, stamens 6, petals all alike. *Tradescantia.* (1)
1. Bracts spathe-like stamens 3. *Commelina.* (2)

1. **Tradescantia** L. Spiderwort.

Herbs with simple or branched stems, somewhat mucilaginous; leaves rather narrow and elongated; inflorescence in terminal or axillary cymes subtended by bracts; perianth of 3 sepals and 3 petals; stamens 6, usually all alike, bearded; ovulary triolcular; capsule loculocidal.

1. Leaves linear, 12–50 times longer than broad, stems elongated. 2.
1. Leaves lanceolate, 2–10 times longer than broad, and zigzag. *T. pilosa.*
2. Foliage glaucous pedicle glabrous, sepals often with a tuft of hairs at the apex. *T. reflexa.*
2. Foliage bright green, peduncles and sepals villous with non-glandular hairs. *T. virginiana.*

1. **Tradescantia reflexa** Raf. Reflexed Spiderwort. A slender, glabrous, glaucous herb. Leaves narrow, linear-attenuate, strongly involute, rather rigid with sheaths; inflorescence a densely-flowered cyme; 2 involucral bracts reflexed; sepals glabrous except the tips which are tipped with tufts of hairs; petals blue. In sandy or loamy soil. Ashtabula, Erie, Mahoning, Richland, Coshocton, Licking, Franklin, Auglaize.

2. **Tradescantia virginiana** L. Virginia Spiderwort. A stout bright-green herb, glabrous or slightly pubescent; leaves nearly flat, linear-lanceolate, long acuminate; bracts leaf-like, inflorescence usually a solitary, terminal cyme; pedicels and sepals villous; petals blue or purple, showy. In rich soil in woods and along railroads. General as far north as Auglaize and Stark.

3. **Tradescantia pilosa** Lehm. Zigzag Spiderwort. A stout herb, commonly flexuous, often branched, more or less puberulent or short-pilose; leaves broadly lanceolate, acuminate at the apex, darker green above than below; pedicels and calyx pubescent and more or less glandular, rarely somewhat glabrous; petal lilac-blue. In thickets and on shaded hillsides. Montgomery, Clermont, Hamilton.

2. **Commelina** L. Day-flower.

Succulent, branching herbs, with short-petioled or sessile leaves. Inflorescence a sessile cyme subtended by spathe-like bracts; sepals slightly united, of unequal size; petals unequal, 2 large and one small; stamens 3 or 2 fertile and 3 or 4 sterile.

1. **Commelina virginica** L. Virginia Day-flower. A branched somewhat pubescent or glabrous herb. Leaves lanceolate, or linear-lanceolate, acuminate at the base; sheathes inflated, often pubescent; inflorescence a cyme surrounded by 2 bracts; corolla showy. In moist soil. Montgomery, Clermont, Lake.

JUNCACEAE. Rush Family.

Perennial or sometimes annual, grass-like, usually tufted herbs. Leaves with sheathes either open or closed; inflorescence a panicle, cyme, corymb, or umbel, spike or head, or rarely, flowers single; flowers small, regular, with or without bracts; perianth of 6 glumaceous segments; stamens 6 or 3 or rarely 5 or 4; carpels 3; fruit a loculicidal capsule, seeds many or 3; endosperm fleshy.

1. Leaf-sheathes open, seeds many, plants never hairy. *Juncus.* (1)
1. Leaf-sheathes closed, seeds three, plants usually hairy. *Juncoides.* (2)

1. **Juncus** L. Rush.

Usually perennial herbs with leaf-bearing stems, and open leaf sheathes. Leaves grass-like or channeled; inflorescence a panicle or corymb, often unilateral, or congested in heads; stamens 6 or 3, ovulary unilocular or trilocular; seeds several or many, sometimes caudate. Commonly found in swamp habitats.

Synopsis.

I. Inflorescence apparently lateral.
  1. Flowers bracteolate, inserted singly.
    J. effusus.
    J. balticus.
  2. Flowers not bracteolate, in heads.
    (No Ohio species.)

II. Inflorescence terminal.
  1. Leaf blades flat or channeled, not septate.
    a. Flowers bracteolate, never in true heads, sometimes clustered.
      J. dudleyi.
      J. tenuis.
      J. bufonius.
      J. monostichus.
    b. Flowers not bracteolate, in true heads.
      J. articulatus.
      J. marginatus.
  2. Leaf channeled or terete, hollow, with septa.
    a. Leaf blades more or less channeled, septa usually imperfect, not externally evident. (No Ohio species.)
    b. Leaf blade usually not channeled, septa perfect and usually evident externally.
      (a). stamens 6.
        J. richardsonianus.
        J. articulatus.
        J. torreyi.
        J. nodosus.
      (b). stamens 3.
        J. brachecephalus.
        J. acuminatus.
        J. canadensis.
        J. scirpoides.

Key.

1. Inflorescence apparently lateral. 2.
1. Inflorescence terminal. 3.
2. Perianth parts greenish, turning straw-colored, stamens 3. *J. effusus.*
2. Perianth parts with a chestnut strip on each side of the midrib, stamens 6. *J. balticus.*
3. Leaf blade flat or channeled, not septate. 4.
3. Leaf-blade channeled or terete, hollow, with septa. 9.
4. Flowers bracteolate, never in true heads, sometimes clustered. 5.
4. Flowers not bracteolate, in true heads. 8.
5. Auricles at the summit of the sheathe cartilaginous and darker than the stem, not extended conspicuously beyond the point of insertion. *J. dudleyi.*
5. Auricles at the summit of the sheathes scarious. 6.
6. Inflorescence with 3-12 secund flowers along the usually dichotomously branched stem. *J. monostichus.*
6. Inflorescence 2-4-flowered, scattered along the dichotomous branches or sometimes aggregate at the top but not second. 7.
7. Bracts exceeding the inflorescence, plants perennial, flowers usually in clusters of 3-4. *J. tenuis.*
7. Bracts shorter than the inflorescence, plants annual, flowers scattered singly along the usually dichotomous branches. *J. bufonius.*

8. Heads of the inflorescence 5–15, each head usually 5–10 flowered, plants less than 20 in. high. *J. marginatus.*
8. Heads of the inflorescence usually 20–100, each head 2–5 flowered, plants over 20 in. high. *J. aristulatus.*
9. Glomerules loosely few-flowered, hemispherical. 10.
9. Glomerules densely many-flowered, spherical. 13.
10. Stamens 6, or if 3 the glomerules only 3–7 flowered; capsule longer than the perianth segments. 11.
10. Stamens 3, glomerule 5–many flowered, capsule shorter than the perianth segments. *J. acuminatus.*
11. Stamens 6, seeds not with caudate tips. 12.
11. Stamens 3, seeds with caudate tips. *J. brachycephalus.*
12. Plants articulate, sepals acuminate, flowers brownish, capsule gradually tapering to a mucronate tip. *J. articulatus.*
12. Plants not articulate, sepals blunt, often mucronate-tipped, flowers straw-colored, capsule acute, or obtuse with a short tip. *J. richardsonianus.*
13. Involucral leaf usually much exceeding the inflorescence stamens 6. 14.
13. Involucral leaf usually shorter than the inflorescence, or if exceeding the inflorescence then not over one inch long, stamens 3. 15.
14. Sepals exceeding the petals, leaf-blades abruptly divergent from the stem. *J. torreyi.*
14. Sepals shorter than the petals, leaf-blade erect. *J. nodosus.*
15. Capsule obtuse or acute at the apex, sometimes mucronate but not prolonged into a beak; seeds with definite caudate tips. *J. canadensis.*
15. Capsule tapering evenly into a prominent subulate beak; seeds blunt or merely pointed, not caudate. *J. scirpoides.*

1. **Juncus effusus** L. Common Rush. An herb with a branching root-stock, lateral inflorescence and non-septate leaves. Basal leaves reduced, scapes soft and pliant; inflorescence a diffused, much-branehed cyme; flowers small and greenish; stamens 3; style short; capsule trilocular; seeds small. Marshy ground. General and common.

2. **Juncus balticus** Willd. Baltic Rush. Scape rigid; inflorescence a lateral, loose or dense cyme; perianth parts brown with a green mid-rib and hyalin margins; capsule about as long as the perianth, brown mucronate, trilocular. On sandy soil. Erie County.

3. **Juncus dudleyi** Weig. Dudley's Rush. Infloreseence a terminal cyme subtended by bractlets; leaves non-septate; leaf-sheath covering ¼ of the stem; aurieles dark, cartilaginous not conspicuously extended beyond the point of insertion; seeds blunt. Montgomery, Clinton, Champaign, Licking, Delaware, Tuscarawas.

4. **Juncus tenuis** Willd. Slender Rush. Infloreseence terminal, subtended by bracts; flowers subtended by bractlets; sheaths covering ¼ of the stem; leaves flat, non-septate, becoming involute in age; auricles scarious, conspicuously extended beyond the point of insertion. Seeds blunt. General.

5. **Juncus bufonius** L. Toad Rush. An annual herb, 8 in. high, with terminal inflorescence and non-septate leaves. Flowers scattered singly along the one sided and usually dichotomously branched inflorescence; leaf blade flat; stamens 6 or 3; capsule trilocular. Williams, Lucas, Lorain, Licking.

6. **Juncus monostichus** Barth. One-ranked Rush. Plant 12–20 in. high; culms compressed; inflorescence terminal; leaves basal and involute in drying; auricles scarious; inflorescence exceeded by the bract; flowers secund. Trumbull County.

7. **Juncus aristulatus** Mx. Small-headed Grass-leaf Rush. Inflorescence terminal, usually composed of from 10–20 heads, each head of from 2–5 flowers; stamens exserted and persistent in the fruit; capsule rarely exceeding the calyx. Fairfield, Summit.

8. **Juncus marginatus** Rostle. Grass-leaf Rush. Inflorescence terminal, of 2–20 heads, each with 5–10 flowers; flowers not subtended by bractlets; capsule rarely exceeding the calyx; stamens exserted and persistent in the fruit. Cuyahoga County.

9. **Juncus richardsonianus** Schult. Richardson's Rush. Inflorescence in terminal heads with fasicles of leaves; leaves septate, upper cauline leaves with blades; sepals blunt; stamens 6; seeds blunt. Cuyahoga County.

10. **Juncus articulatus** L. Jointed Rush. Leaves septate, upper cauline leaves with blades; inflorescence in terminal, spherical glomerules; sepals acuminate; stamens 6; seeds blunt. Cuyahoga County.

11. **Juncus torreyi** Cov. Torrey's Rush. Leaves septate, upper cauline leaves with blades; inflorescence in terminal, spherical glomerules; petals shorter than the sepals; stamens 6; seeds blunt. Cuyahoga, Adams, Madison, Wood and Erie.

12. **Juncus nodosus** L. Knotted Rush. Leaves septate, upper cauline leaves with a blade; inflorescence in terminal, spherical glomerules without fasicles of leaves; involucre exceeding the inflorescence; sepals subulate; stamens 6; petals equaling or exceeding the sepals. Madison, Cuyahoga, Erie, Franklin.

13. **Juncus brachycephalus** Engelm. Small-headed Rush. Leaves septate, with well developed blades; inflorescence in terminal, 2–5 flowered heads; stamens 3; seeds with short caudate tips. Erie, Cuyahoga, Champaign, Franklin, Madison.

14. **Juncus acuminatus** Mx. Sharp-fruited Rush. Leaves septate, blades of the lower leaves 4–8 in, long; inflorescence terminal, branches of 5–50 heads, rarely more or less, heads 3–20 flowered; petals and sepals nearly equal; stamens 3; seeds tipped at each end. Ashtabula, Lake, Lorain, Cuyahoga, Huron, Portage, Tuscarawas, Knox, Union, Licking, Auglaize, Carroll, Champaign, Fairfield, Adams, Brown.

15. **Juncus canadensis** J. Gay. Canada Rush. Leaves nodose, basal leaves disappearing before flowering time; sheathes with auricles, inflorescence in terminal, crowded heads, with 5–50 flowers to the head; stamens 3; capsule mucronate, reddish brown, longer than the perianth; seeds with a definite tail. Cuyahoga, Licking, Auglaize, Madison, Geauga.

16. **Juncus scirpoides** Lam. Scirpus-like Rush. Leaves septate, blade of the uppermost leaf longer than the sheath; inflorescence in densely flowered heads; stamens 3; capsule attenuate, exceeding the calyx; seeds blunt. Erie County.

2. **Juncoides** Adans.

Perennial plants, glabrous or hairy, with grass-like leaves and closed leaf sheathes. Inflorescence an umbel, panicle or corymb; flowers with bractlets; stamens 6; ovulary unilocular, three-seeded.

1. Flowers occurring singly or in twos at the ends of the branches of the inflorescence. *J. pilosum.*
2. Flowers occurring in glomerules. *J. campestre.*

1. **Juncoides pilosum** (L.) Ktz. Hairy Wood-rush. A tufted herb, often stoloniferous. Stems erect, 2–4 leaved, 6–12 in. high; leaf blades flat, acuminate; inflorescence an umbel, each pedicel 1 or 2 flowered; perianth brown with hyalin margins; seeds hooked. Lucas, Cuyahoga, Trumbull, Mahoning, Hocking.

2. **Juncoides campestre** (L.) Ktz. Common Wood-rush. Tufted herb, 4-20 in high; stems 2–4 leaved; leaf blades blunt, pubescent, inflorescence an umbel, lower bracts leaf-like, acuminate; flowers brown, capsule obovoid or broadly oblong. In woods. General.

Xyridaceae. Yellow-eyed-grass Family.

Tufted, rush-like herbs with narrow, two-ranked leaves and leafless scapes. Flowers in heads, bisporangiate, mostly yellow, solitary and sessile in the axils of bracts; petals 3; sepals 3, unequal, one large and membranous and 2 small and keeled; stamens 6 or 3; ovulary tri-or unilocular; ovules orthotropous; fruit a capsule; endosperm mealy.

Xyris L. Yellow-eyed-grass.

Perennial herbs with the flowers single in the axils of coriaceous scale-like bracts, which together form a head. Stamens 3 fertile and 3 sterile; capsule unilocular, many seeded.

1. **Xyris flexuosa** Muhl. Slender Yellow-eyed-grass. An herb 5–20 in. high, with a slender, straight or slightly twisted scape. Leaves flat, becoming twisted; inflorescence globose or oblong or obtuse; lateral sepals linear and fringed with short hairs on the wingless keel. In bogs. Portage, Geauga.

ERIOCAULACEAE. Pipewort Family.

Stemless or short-stemmed, perennial or annual, bog or aquatic herbs, with fibrous or spongy roots, monecious or diecious; scape long, bearing a solitary terminal head of small monosporangiate flowers, each borne in the axil of a scarious bract; perianth segments 6 or 3, stamens 6 or 3; ovulary 2 or 3-locular; fruit a loculocidal capsule; seeds orthotropous; endosperm mealy.

Eriocaulon L. Pipewort.

Stemless or short-stemmed, monecious herbs with erect scapes and short, spreading, acuminate, parallel-veined leaves. Inflorescence a tomentose head, white to almost black, staminate flowers with 6–4 stamens opposite the perianth segments, ovulary vestigial, carpellate flowers having a stalked or sessile ovulary with no stamens; fruit a capsule.

1. **Eriocaulon septangulare** With. Seven-angled Pipewort. Monecious aquatic herbs with almost no stem from which arise soft, awl-shaped, pellucid leaves and a weak, twisted scape somewhat seven-angled. Involucral bracts glabrous or the innermost ones bearded to the apex, shorter than the flower; outer flowers of the head usually staminate; carpellate flowers generally smaller than the staminate; perianth segments white, bearded. In still water or on shores. No known specimens from Ohio.

A PRELIMINARY LIST OF THE ACARINA OF CEDAR POINT.

CHAS. K. BRAIN.

Acarina were collected between July 20th and August 15th, 1912, in the vicinity of the Lake Laboratory, Cedar Point. Attention was paid for the greater part to those mites found along the edge of the Cove, and most specimens were taken from boards found lying at the edge of, or in the water. Most of the material was mounted as collected, and some thirty slides submitted to Prof. Nathan Banks who very kindly consented to make the determinations for me. Named slides have been deposited with Prof. H. Osborn, Director of the Laboratory, and the only excuse for publishing such an incomplete list is the hope that some worker will continue the study of this important group in the near future.

1. Anystis agilis Banks. On fungus beetle *Boletotherus bifurcus.*
2. Celænopsis americana Banks. On *Hololepta* sp.
3. Celænopsis pedalis Banks. On larva of *Passalus cornutus* Say.
4. Cunaxa quadripilis Banks. On board at edge of Black Channel.
5. Galumna emarginata Banks. On board at edge of Black Channel.
6. Galumna pratensis Banks. On log N. W. of Lake Lab.
7. Hydrachna sp. On board floating at edge of Black Channel.
8. Hydrachna sp. Larva of. In tow-net. Black Channel.
9. Hydrachna sp. Larva of. On *Zaitha fluminea.*
10. Hygrobates sp. On board floating at edge of Black Channel.
11. Macrocheles sublævis Banks. Common on fungus beetle *Boletotherus bifurcus.*
12. Oribatodes sp. On board floating at edge of Black Channel.
13. Oripoda sp. (probably n. sp.) On board at edge of Black Channel.
14. Parasitus inæqualis Banks. Common on *Silpha americana.*
15. Parasitus sp. Young of. On decaying fungus. *Strobilomyces strobilaceus* Berk.
16. Parasitus sp. Nymph of. Found commonly on board floating at the edge of Black Channel.
17. Polyaspis lamellipes Banks. On *Orthosoma brunneum* Forst. Also found attached to legs of *Parandra brunnea.*
18. Rhyncholophus pilosus Banks. Collected by sweeping *Tilia Americana.*
19. Rhyncholophus sp. Larva of. Attached to *Melanoplus bivittatus.* Say.
20. Sciulus sp. Nymph of. On cotton-wood log.
21. Stractides sp. in tow-net near entrance to Black Channel.
22. Tetranychus bimaculatus Harvey. Common on plants near Lake Lab. dock.
23. Trombidium sp. Larva of. On *Musca domestica* Linn.
24. Tyrrellia circularis Wolcott. On board at edge of Black Channel.
25. Uropoda sp. On *Hololepta* sp.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, December 2, 1912.

The meeting was called to order by the President, W. G. Stover.

The presentation of papers followed the reading and approval of the minutes.

Mr. C. K. Brain gave the first paper on the "Internal Anatomy of Stomoxys calcitrans." This blood-sucking fly had been suggested as the agent in transmitting blood diseases in India and other tropical countries, some time back. In October of the present year, Rosenauer declared it to be the host of a part of the life cycle of the organism causing infantile paralysis, and transmits that disease. Anderson and Frost's work on monkeys in November, confirmed the idea.

Experiments by the Ohio State Board of Health point to a mechanical transmission by Stomoxys.

The digestive systems of Stomoxys and Anopheles, the malaria mosquito, were compared in detail and figured. The conditions in Stomoxys appear to be on the whole more complicated and elaborate than in the mosquito, though there is some reduction in number of mouth parts and no distinction between sexes can be made on the basis of mouth parts.

The abdominal sucking stomach and the abdominal position of the salivary glands are noticeable features in Stomoxys.

Prof. Landacre talked on the "Production of Germinal Variations." He spoke particularly of the work of Dr. Tower who has produced variations in the color patterns and antennæ of beetles by altering conditions of temperature and moisture. This work seems to give the best of the argument to the transmissionists.

Mr. W. G. Stover exhibited some specimens of Oklahoma fungi, calling attention especially to the wood forms, the grass forms, and the stink-horns. A number of these Oklahoma fungi are also found in Ohio.

The following persons were elected to membership in the Club: Walter R. Wheelock, Lillian E. Humphrey, Ralph R. Jeffries, Po Chen, Mary Storer.

The meeting was then adjourned.

Marie F. McLellan, *Secretary.*

Date of Publication, April 28, 1913.

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THE OHIO NATURALIST

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Especially to *the* Natural
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UTILIZATION AND CONTROL OF AQUATIC RESOURCES OF OHIO.*

HERBERT OSBORN.

In attempting to present the matter of conservation of the resources of our State, I realize that the problem is so large that even to discuss one phase of it is more than I can expect to do, but the importance of the matter is such that I desire to contribute what I may in this direction. While the aquatic resources have been perhaps less recognized than the ordinary resources in agriculture and mining, we cannot question their close relation to other lines of development, and especially in agriculture a most important relationship exists. Considering the aquatic resources by themselves we must include the phases of aquatic dependence for agriculture, manufacture and commerce, and a careful examination of the problems will show that these are most intimately blended, and in reality mutually serviceable.

In arid regions the term "duty of water" is used to indicate the service that water should perform, and this term might be used with reference to our aquatic resources, but perhaps we may speak in a broader sense of the service of water as a recognition of its utility in all the varied activities of our commonwealth. We must appreciate its necessity in agriculture, its importance in furnishing water supplies in cities for domestic purposes and for power and for navigation, and in short its constant use in all human activities. Taking the state at large, we have approximately forty inches of rain-fall each year, and this represents a certain amount of basis for the numerous activities

*Read before the Ohio Academy of Science at its conservation session, Nov. 27, 1908.

of the state, just as essential and permanent an asset as the soil itself. Unquestionably a large amount of service is derived from this body of water. It is, I believe, equally certain that an immense amount of this resource is going annually to waste, and that by its proper utilization the wealth of the state could be very greatly increased.

While it is not my purpose to go into detail regarding all phases of this problem, I may call attention to the service of water in connection with agriculture, where we have a large amount of utilization, and where there is perhaps less of necessity for changes in method of operation. For service in production of crops it is necessary that the annual rain-fall be absorbed in the soil, that a certain amount be retained for support of plant life during intermittent periods of dryness, and to a large extent this is met in the ordinary methods of culture, especially in connection with systems of tile drainage which are now largely in vogue. The practical necessities in preservation of soils is admirably stated by Professor Chamberlain in a recent article in Popular Science Monthly,* which I take the liberty to quote:

> "The key to the problem lies in due control of the water which falls on each acre. This water is an asset of great possible value. It should be the habit of every acre-owner to compute it as a possible value, saved if turned where it will do good, lost if permitted to run away, doubly lost if it carries also soil values and does destructive work below. Let us repeat the story of its productive paths. A due portion of the rainfall should go through the soil to its bottom to promote soil-formation there; a due portion of this should go on into the under-drainage, carrying harmful matter; a due portion should go again up to the surface carrying solutions needed by the plants; a due portion should obviously go into the plants to nourish them; while still another portion should run off the surface, carrying away a little of the leached soil matter. There are a multitude of important details in this complex of actions, but they must be passed by; the great features are clear and imperative."

It may be noted in passing that this service of water by no means affects its further service in other ways, but that the more complete the retention of the soil, the more equal the distribution of the flow, the more perfect is its availibility for other purposes. My understanding of the effect of tile drainage is that it provides for the greater absorptive power of the soil, so that a larger portion of the rainfall goes into the soil, reducing the surface wash, providing for the retention of organic matter, and regulating the outflow.

With regard to the utilization of the waters of the state for power, it appears that there is opportunity for an immense development. There are hundreds of sites where some considerable amount of water could readily be impounded, and power for electric-lighting and running of machinery be developed on a large

*July, 1908, Vol. LXIII, p. 5.

scale. There are many other localities which have such power in a smaller degree for the running of small local plants in various industries.

This feature is also closely associated with the greatest utility of water in irrigation and navigation, as the retention of waters during flood periods is the evident means of prolonging the periods in which irrigation or navigation is possible. This problem is essentially an engineering problem, and I would like to present some quotations from the report of an engineer who has evidently given this problem a great deal of study. His paper entitled "The Mississippi River Problem" while covering the whole Mississippi River drainage, is in large part a discussion of questions pertaining to Ohio, and it seems to me distinctly appropriate in this connection. It certainly fits in most perfectly with any efforts toward the retention of our own rainfall, its utilization and the reduction of flood damage within the state. He says:

"The solution by building a series of reservoirs in the head-waters of the chief tributaries appears to be the cheapest and most certain remedy for all these difficulties. By the construction of reservoirs the excess of water which produces flood stages could be impounded and held up with these important results: Excessive and destructive high-water stages could not occur, while, on the other hand, by regulating the discharge from the reservoirs, a more even flow of water could be maintained at all times, eliminating to a large degree the losses from diminished water supply, reduced power and fouling of streams incident to the low stages of late summer and early autumn. As soon as the irresistible rush of flood waters is stopped the sapping and caving of banks will be reduced to a minimum, with the efficiency of revetments increased many fold; finally, cutting down the flood volumes means a great dimuintion of the amount of sediment carried, and a marked alleviation of the sand-bar evil. The reservoirs would, moreover, eliminate floods from the whole system, not merely from the lower course. The prevention of the annual flood damage in the Ohio would in itself be worth the entire cost of the reservoirs, yet until the work of control is carried to the headwaters no relief can be secured for that populous valley.

"The solution by head-water reservoirs, of all proposed plans, has probably provoked the most discussion—on the one side, those who regard it as impossible, or, at least, highly impracticable; on the other side, those who consider that it is not only feasible but at once the only proper remedy. It is admitted by every one that the topography of the country about the head-waters of the Mississippi system is especially well adapted to the construction of retention dams and reservoirs. The arguments advanced against this plan, though admitting this condition of favorable topography, maintain that sufficiently large reservoirs could not be constructed and made safe or, in other words, they would, through danger of bursting, be a constant menace to the whole valley below the retaining dam. Again it is urged that if this plan were adopted, the building of reservoirs would have to be done on an enormous scale, since destructive floods often result from local conditions, such as a swollen tributary superimposed on an already swollen river. This necessity for a widely extended system of reservoirs, it is further claimed, would involve such tremendous expense as to make the adoption of the plan impossible. Most of these supposed objections are still based on a report made to Congress nearly fifty years ago, and, whether good or bad arguments then, there is no question that they do not apply now."

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*Tower, W. S. "Popular Science Monthly," July, 1908. Vol. LXIII, p.13.

"It is flying in the face of cold facts to contend any longer that reservoirs to retain the flood waters can not be built, or not without danger to the entire valley below. The Ohio floods of 1907, the most disastrous for more than two decades, were due to an excess of water estimated at 23,000,000,000 cubic feet. To hold every drop of that excess discharge would have required a reservoir only a little more than half as big as the Pathfinder irrigation storage reservoir on the North Platte River in Wyoming, or one-third of the size of the reservoir in the Salt River project in Arizona. The Engle dam on the Rio Grande, a hundred miles north of El Paso, Texas, will impound about 120,000,000,000 cubic feet of water, equal to one-sixtieth of the total annual discharge of the entire Mississippi system, or more than five times the quantity of water causing the most destructive Ohio flood in a score of years. These reservoirs are being built by the government at a cost of about $4,000,000 for the Pathfinder dam, $5,300,000 for the Salt River project and $7,200,000 for the Rio Grande reservoir. Furthermore, it is expressly stated by the Reclamation Service that the Wyoming reservoir and the Engle dam will absolutley control the worst floods which the North Platte and the Rio Grande have ever known, the latter of these streams having been a notorious offender in flood damage. The mere fact of being able to retain the flood waters in impounding reservoirs can no longer be denied, nor can the claim of danger from breaking dams be now advanced as a valid argument against this system. This government is most assuredly not spending millions in reclamation projects and encouraging thousands of people to take up irrigated lands if there is any remote likelihood of having homes, property and lives wiped out in floods from bursting reservoirs.

Granting, then, that the reservoirs are feasible, there still remains the question of expense in constructing the number necessary to place one or more in each of the most important tributaries. Estimate the expense most generously, letting each one cost a third more than the Engle dam above El Paso, and the total figure then is less than what has already been spent on the Mississippi system. But there is another important factor to be considered—the tremendous possibilities which lie in the development of water power from each reservoir. The question of furtue motive power for industrial purposes, as the coal supply decreases, is a problem which must soon be met in this country, and probably will be solved by the use of water power either directly or through electricity. In fact, even now, water rights are being rapidly acquired and developed on every hand, as the advance guard of the change that is to come. A sample of what a storage reservoir will do can be seen in the case of comparatively small irrigation project at Minidoka, Idaho, which will develop about 30,000 horse power per year. Renting this power at the very low figure of $10 per horse power per year would pay for the entire Minidoka project, reservoir, irrigation-canals, gates and all, in six years. The amount of power generated by the Mississippi system is variously estimated high and low, with 60,000,000 horse power per year as an intermediate figure. Much of this amount is not directly available, but granting on a conservative basis that a series of impounding reservoirs would develop immediately 2 per cent of that amount, there would be 1,200,000 horse power to be turned into electricity and distributed to factories. A purely nominal rental would be ample enough to repay in two or three decades the entire original expense of the system, besides a good income on the investment. The reservoir system, however, must be intimately associated with forest conservation as a vital factor in regulating surface drainage and in checking the amount of soil erosion which supplies sediment to the river.

The proper building of reservoirs in the headwaters, therefore, offers what no other plan can possibly offer: it promises effective regulation of river stages and water supply for all time to come, removing entirely the

liability of destructive floods, checking the erosion of banks and preventing much of the formation and shifting of sand bars and the pollution of water which the presence of sediment means. At the same time it provides a way of actually paying for itself in short order, aside from all idea of the savings to shippers and river interests in general which would be in excess of the cost. The importance of this latter consideration is emphasized best by a brief comparison with the system now being followed. The levee-revetment system, as mapped out, calls for an expenditure of $60,000,000 for its completion. From the engineers themselves comes the statement that the average life of a levee is not over twenty years, which means this and no more; in two score years, at the most liberal estimate, the present system, completed, will have disappeared entirely and a new series of levees constructed at the cost of another $60,000,000 will have taken its place, with conditions then no better than they are now. Considered solely on their own merits from the standpoint of control afforded, the present system has nothing, and the reservoir plan has everything, to recommend it.

"In order to bring the river route to its highest possible degree of efficiency, it would be necessary to combine the reservoir system with a straightened course for the lower river, by which combination every evil would be removed and absolute control for all time would be insured. The reservoirs would make it possible to regulate the flow of the streams, preventing both floods and very low water, and at the same time, through developed horse power, pay for the improvements. The corrected or straightened course would shorten the route and effectively put an end to caving of the banks with all the difficulties arising from it at present. Together the reservoirs, with the necessary forest conservation and corrected course, would remove the sand bar problem—the one greatly lessening the actual amount of sand carried into the river, the other giving the current increased power to sweep its own channel clean."

While it is probable that some of the advantages claimed may not be entirely realized, especially in the case of extreme flood there is, it appears to me, so much of virtue in what this author claims that it should be given great weight in any general plan of flood control. It appears, however, that such a method should be strongly re-enforced not only by the conservation of forests and thickets on uplands and hill sides in the head waters of streams, but that the stream valleys should, to as large an extent as possible, be planted in willow and other moisture loving shrubs or trees, which serve as a natural check to the stream currents and therefore retard the flow and serve to distribute it through a longer period of time.

There is another phase of the subject, and the phase which appeals directly to me. That is the biological side of the problem of utilization of water. While this phase seems to have been largely neglected, it appears to me that it is worthy of fully as much consideration as the utilization for power or navigation and particularly in connection with its bearing on flood control. The neglect of this phase is probably due to the fact that in our ordinary processes of culture we have come to consider water in excess as undesirable and make efforts to eliminate it rather than to conserve it. For the culture of our ordinary crops it is, of course, true that an excess of moisture is detrimental, and tile

drainage combined where possible with irrigation is a natural remedy for this condition. There is, however, no question that beyond this we have in water areas a source of production which is very extensive, and which, were it brought under the proper system of cultivation, would furnish a great source of wealth. We are all familiar with the rank growth of swamps and low-lands, and can readily appreciate that for certain kinds of vegetation a constant or even excessive supply of water is in no degree detrimental. There is however, in addition to the evident growth, an enormous development of microscopic life familiar to the biologist, but practically ignored by those unfamiliar with aquatic life.

"Some of this becomes apparent as green scum or as floating masses when its growth exceeds the capacity of the aquatic animals to consume it. Sometimes these minute algae become a great source of annoyance in water supplies if for any reason their multiplication is unchecked, since they give offensive odors and taste to the water.

"It has been estimated that the rate of development in some of these organisms is such that the possible progeny of one individual would suffice to fill all the waters of the globe in less than a week.

"This is significant to us here simply as showing the enormous possibility of these organisms in utilizing water and air in the formation of vegetable substance, which substance may, with proper utilization, be transformed into fertilizing agents for the production of valuable plant crops or into animals having direct commercial value. To understand this process, let us consider for a moment the relations existing among aquatic organisms. The algae may be considered among the more simple and these develop with only water and air or the other inorganic contents of water, but they furnish food for an innumerable host of microscopic animals such as amoebae, rotifers, etc., and these in turn are fed upon by others, such as microscopic crustacea, which again form an important part in the diet of young fishes. These when grown, or after furnishing the basis of food for other larger species, may reach our tables as human food. This, however, is but one line of transformation, as we have fishes of very different habits utilizing different kinds of aquatic life as food.

"Where the life taken from the water does not balance the production, or where this product is not drained off into the sea, the accumulation of organic debris forms at the bottom a mass of richest organic matter, which by its decomposition may in a large part result in marsh gas, and in this form escape into the air. * * *

"We have in America practically no established system of cropping our water areas. * * * Something has been accomplished in fish culture in some sections, but even here the full utilization of the resources of a body of water are but poorly accomplished. A few sporadic efforts have been made here and there in the culture of frogs and turtles, but how many of them with such attention to the subject as to warrant the term culture?" * * *

The farmer who drains and cultivates an acre of swampy land on his farm gains that much additional space for his ordinary culture and for a time at least it may be unusually productive as it contains the accumulated organic debris of years, but would it not be far greater wisdom to dredge out occasionally a portion of this accumulation to spread upon higher ground and keep the

acre as a source of fertilizing material for the years to come. This seems all the more desirable when it is remembered that this basin must collect quantities of the finest and most fertile parts of the soil washed from the higher ground. Moreover, I hope to show that there is good reason to expect that the acre can be made so productive over and above this function of conserving fertility that it will be worth more in water than it could be as cultivated land.

What is needed in the matter of utilization of our great tracts of marshy or swampy land is some such systematic study and the development of some such adapted system as is in progress of development in the systems of "dry farming" in the arid or semi-arid regions of the west—a system which will intelligently conserve and utilize our heritage of water, not throw it ignorantly away and reduce our uplands to a condition of sterility."*

There are certain resources among the natural inhabitants of aquatic areas, and a few of these may be enumerated to advantage. First perhaps in general recognition is the fish industry which in many localities is a quite important matter. In large part, however, the fish industry is carried on without particular regard to the methods by which the largest available crop could be secured, and except as efforts are made to save and rear eggs of certain species and to regulate the capture for certain seasons, no systematic plan is in practice by which the crop may be regularly grown and harvested, so as to provide for perpetuation. In many localities, especially in swampy areas, the growing of frogs, turtles, ducks, geese and musk-rats is sufficiently recognized to indicate that these are all capable of a much greater cultivation, and there can be no question that a systematic study of the means of culture and adaption to the best localities would result in productive crops. Aside from these there are several species of fur-bearing animals, especially the beaver, otter and mink, which in wilder tracts might undoubtedly be grown with profit. In streams and ponds where the native species of clams used to abound, there unquestionably could be established a productive industry in the growth of these animals for pearls, and as a basis for the button industry. While not yet developed, there is, in all probability, a great latent resource in the aquatic plants which might be used for the manufacture of paper. Some of the species that are native here seem likely to furnish an excellent fibre, but if not, the introduction of other species, especially the Japanese paper plant, might establish a most important industry and serve to relieve in part the drain upon the forest areas which are being consumed in the manufacture of paper. Willows and other rapid growing semi-aquatic trees might also be utilized in this direction, as well as for their influence in checking the outflow of flood waters.

*Osborn, Pop. Sci. Monthly, July, 1908, Vol. LXIII, p. 85–87.

It is estimated in a recent article in the National Geographic Magazine that Ohio contains 1250 square miles of swamp. or, in other words, 800,000 acres, and this area is now practically unused except perhaps to some extent as a hunting ground, but without control or regulation regarding the protection of certain species further than is given by the general laws regarding the killing of game. That this area could be profitably converted into a permanent water area for the retention of rain-fall, and by a system of canaling made into cultivable land or water, seems certain. Estimating the capacity of such an area we would have for one foot of water nearly thirty-five billions of cubic feet, or for two feet of increased depth nearly seventy billions of cubit feet, which, if compared with the previous estimates as to the excess of outflow responsible for serious floods, will seem to have a very direct importance. If it be recognized that this area could be kept in water, and at the same time produce valuable crops, the advantage of preserving this resource will be apparent.

It seems, therefore, that the general policy for the conservation and utilization of water which is a very constant element in our state wealth, should be that of retention and culture for various crops, rather than a rapid discharge by drainage applied to all swampy land. This is perhaps the main point involving a radical departure from present policies, but this is of immediate importance since there are constant efforts in the drainage of existing swamps, and once these swamps are drained, a re-establishment of the conditions for retention of water will be very difficult, if not impossible.

To the engineer a drainage scheme is perhaps the most attractive, since it presents definite possibilities in the disposition of water, but from the biological standpoint the retention of water seems far more important. Ohio already has a distinct start in the direction of reservoirs in the Grand, Lewiston and Licking reservoirs, which are bodies of considerable size. Although designed originally in connection with the canal system of the state, they are capable of serving for other purposes without in any degree affecting their value for the original purpose. Abundant sites exist in the state for the construction of additional reservoirs, largely in the valleys which are not of great value for other purposes, and which in the aggregate would furnish a large capacity. The Columbus storage dam containing 1,600,000,000 cubic feet with the present thirty-foot dam occupies a river valley which was practically unused and of slight value for agricultural purposes. A number of such reservoirs suitably located and properly controlled, while nor sufficient to entirely prevent flood conditions, might certainly aid greatly in preventing the excessive flood conditions that result from the immediate outflow of all surplus water, and also serve largely in the improvement of navigation.

They could also be used in suitable localities for extensive systems of irrigation, and finally for the cultivation of aquatic crops. Such crops, although at present problematical, have, I fully believe, a most important promise of wealth.

Considering, then, the quantity and regularity of our water, the extent of the utilization it is already given, and the possibilities in development for irrigation systems, power, and navigation, and especially the possibilities of development for production of important crops, it is no extravagance to claim that it stands as one of our greatest sources of wealth, and merits and demands thorough scientific investigation that these resources may be conserved, developed and utilized to their fullest extent.

In summing up these different factors it seems that the greatest utility of our water supply and its most effective control may be secured with the combination of a number of different methods, but not by depending upon any single one. The following may be offered as suggestive:

First, the levee system serving to narrow and raise a river channel, can serve only to jeopardize the lives and property of the river valley and should be resorted to only in particular cases and in connection with other means of flood relief.

Second, the establishment of as many reservoirs as possible, in the head waters of the smaller tributaries to the larger streams and the utilization of such reservoirs not only for power and as a reserve for water supply, for irrigation and navigation, but also as a basis for the growth of aquatic plants and animals, the cultivation of which should be a subject of careful experiment.

Third, the exhaustive study and development of reforestation wherever this can be done to advantage, and especially the protection of thickets and brush land along the slopes leading to the river bed.

Fourth, the preservation and regulation of all extensive swamp areas which can be made to contribute to water retention in the head waters of the river tributaries.

Fifth, the extensive planting of marsh grass, willows, or any other plants which flourish in the river bottoms, as a means of checking the flow to the streams during periods of excessive rain.

Sixth, the utilization of the river flood plains reached by higher floods for crops which are least affected by over-flows of river water and which provide an opportunity for the spreading out of excessive water and serve also to catch and hold the river silt which forms a most important addition to the soil's fertility.

A CYTOLOGICAL LIFE CYCLE.

Robert F. Griggs.

The figures and diagrams which are usually presented to explain the nature and significance of the reduction division to beginners, although clear enough in themselves, often fail in their purpose because they do not take account of the fact that reduction is indissolubly bound up with fertilization. To give a clear conception of the significance of reduction it is necessary to present the whole life cycle. In many respects the fern is better suited than any other type for the representation of such a cytological cycle. The alternation of generations is obvious; the haploid as well as the diploid condition is evident; the antithetic processes of fertilization and reduction occur at opposite points of the life cycle and can thus be presented far more clearly than when reduction appears to be merely the "maturation of the germ cells."

The diagrams here presented are based on a hypothetical fern with four chromosomes in the sporophyte. The cytology is that of Ascaris* very little schematized. Each of the chromosomes of which two are represented as short and two long, is marked with a characteristic figure so that its permutations may be followed through the cycle.

The best stage with which to begin is the diploid mitosis of the sporophyte, which conforms to the familiar type of somatic karyokinesis generally described. Omitting the resting nucleus the first stage in division is the formation from the chromatin network of a long, continuous spirem which winds in and out more or less, filling the whole nuclear cavity (Fig. 1). Soon each granule of this spirem divides and it becomes double longitudinally (Fig. 2). After considerable contraction during which the chromatin granules are drawn closely together, the spirem breaks into four pieces, the chromosomes (Fig. 3). These are oriented on the spindle and divided longitudinally along the line of the early split (Fig. 4), one half going to each pole and entering into the corresponding daughter nucleus (Fig. 5), so that the progeny of every chromosome is equally divided between the daughter nuclei. As all of the cells throughout the organism are produced in this manner each is exactly like every other in chromatin content and, on the hypothesis that the chromosomes bear the hereditary characters, in heritage as well. That this is actually the case in the heritage as well as in the chromosomes may be demonstrated by the familiar facts of vegetative propagation by which

*See Griggs, R. F., A Reducing Division in Ascaris, Ohio Nat., 6: 519-527, 1906. Wilson, E. B., The Cell, 2d Ed., pp. 65-72, 183, 236-242, N. Y. 1906.

the whole plant complete in all its parts may be reproduced from any small slip which can be made to grow. In some cases e. g. the leaves of Bryophyllum even single cells may be made to propagate the plant which of course would be impossible unless they contained all of the hereditary characters. This type of division continues then until the reduction division occurs and the familiar nonsexual spores so frequently found on fern leaves are produced.

In the reduction division the spirem is formed and divides in the same manner (Figs 6 and 7), but breaks into only half as many pieces as in the ordinary mitosis (Fig. 9). Thus each piece really corresponds to two of the divided chromosomes seen in the metaphase of ordinary mitosis. This pairing or "synapsis" of the chromosomes is the essential difference between the two types of mitosis, for all of the subsequent difference of the reduction chromosomes is the necessary consequence of it. Before they pull apart these paired, doubled chromosomes become definitely associated together forming the variously shaped tetravalent chromosomes or "tetrads" characteristic of the reduction division. In their early stages they may be seen to be formed by the association of the two arms of the loops into which the spirem is thrown (Figs. 7, 8 and 9). As they are pulled apart they may retain the form of the original loop or may appear as crosses or rings depending on their length and the manner in which they are attached to the spindle fibres (fig 10). Curiously enough the pairs are always made up of chromosomes of exactly the same size. This is indicated in the diagrams but becomes much more striking in organisms like the hyacinth with numerous chromosomes of diverse sizes.

In the metakinesis stage of the first reduction division (Fig. 10), the pairs of chromosomes which fused or rather failed to separate in the early stages, are pulled apart so that one goes to each of the daughter nuclei (Fig. 11). Immediately after the first mitosis the spindles of the second mitosis organize at each of the poles and the doubled chromosomes separated in the first mitosis are divided along the line of the early longitudinal split (Fig. 12), giving rise to the nuclei of the four nonsexual spores. Each spore thus contains one of the four parts of each of the tetrad chromosomes of the first reduction division. It will be observed that they are not alike in the chromosomes they bear. One set of spores bears only those designated by circles and dots while the other bears only those designated by crosses. If it had so happened that one of the tetrad chromosomes of the first mitosis had been turned the other side up as is indicated in the alternative Figure 10a, it is clear that the resultant nonsexual spores would have borne a different combination of chromosomes, all of them being mixed as to crosses and dots. When the number of chro-

mosomes is larger as is the case in most organisms and each of the chromosomes is oriented by chance independently of the rest as is presumably the case it is obvious that the number of combinations i. e. the number of kinds of reduced cells increases as the square of the number of chromosomes.

Omitting the variations, however, and following one of the nonsexual spores, say that with chromosomes marked with circles and dots, we find that it produces on germination the familiar heart-shaped gametophyte (prothallus) of the fern. The mitoses occurring in the growth of this plant (Figs. 14 and 18), are exactly similar to those of the sporophyte except that they have only the reduced number of chromosomes found in the spore from which it grew, i. e. they are haploid instead of diploid. When mature the gametophyte produces archegonia bearing eggs, and antheridia bearing sperms. In the development and maturation of these gametes there is, of course, no reduction division.

Fertilization may occur between an egg and a sperm from the same plant or the sperm may come from a different gametophyte. The latter alternative is figured in the diagram and it is further assumed that the sperm came from a gametophyte derived from a spore bearing the chromosomes marked with crosses (Figs. 20 and 21). When the sperm fuses with the egg their nuclei may be in a resting condition or they may be resolved into their respective chromosomes (Figs. 19 22), and proceed at once into the first mitosis of the succeeding embryo and the cycle is complete. (Figs. 23 25).

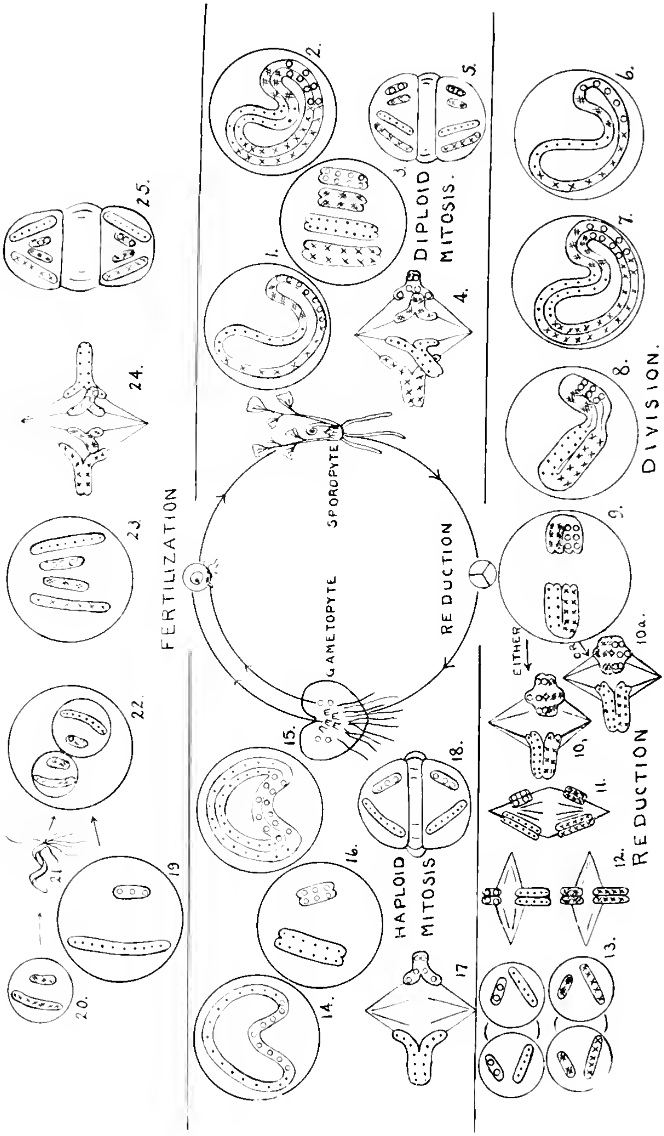
The significance of the conventions adopted in marking the chromosomes thus becomes apparent. Those marked with dots and circles came from the egg parent and those marked with crosses from the sperm parent. In view of this, the fact commented upon above that each chromosome pairs with its appropriate mate in synapsis, takes on a new significance, for each of the tetrad or reduction chromosomes is seen to consist of a doubled chromosome of maternal origin paired with the corresponding one of paternal origin. It is also evident that while the nuclei fuse in fertilization, the chromosomes do not show any sexual affinity for each other and live together, so to speak, in the nuclei of the diploid generation as independent units, until in the first half of the reduction division the corresponding pairs of maternal and paternal chromosomes appear to develop an attraction for one another and finally unite as synaptic mates to form the reduction chromosomes, so completing the union of sexual elements begun at the time of fertilization.

It is obvious, moreover, that if by chance one of the chromosomes had been oriented differently in the reduction division, as indicated by the alternative Figure 10a, none of the spores result-

ing would have borne the same chromosome combination as their parents. The combination diagramed could never be repeated until egg and sperm containing between them the chromosomes represented by all four symbols met and in the resulting zygote the chromosomes were oriented on the spindle in exactly the proper manner and this was followed by a succeeding fertilization by pure gametes bearing respectively only dotted and crossed chromosomes. Thus in an organism with four chromosomes in the diploid generation there are no less than nine possible chromosome combinations, while in organisms with numerous chromosomes the number of combinations possible is 3^n where n is the number of chromosomes.

Without making any specific assumptions concerning differences in specific maternal and paternal chromosomes other than the common knowledge that the plasms of the two parents are in a general way different in heterozygous organisms, it is evident that there is here a mechanism varied enough to account in large measure for the large variability in inheritance which is so familiar No two children of the same parents (except identical twins) are ever alike, be the family ever so large. When we take account of intermarriage even without considering varying racial characteristics it is not surprising that we never find two faces alike.

If however we assume that the long crossed chromosome for example bears a specific character which is absent from its mate the long dotted chromosome, it will be seen that any one of four possible combinations with respect to this one chromosome and the character it bears may be realized in fertilization: (1). An egg bearing the x chromosome may be fertilized by a sperm bearing an x chromosome or, (2), by a sperm bearing a dotted chromosome, (3), an egg bearing a dotted chromosome may be fertilized by a sperm bearing an x chromosome or (4), by a sperm bearing a dotted chromosome. In the first case all of the cells produced in the subsequent reduction would bear the x chromosome together with its character, and if inbred would continue pure ever after. In the fourth case the offspring would be pure in respect to the dotted chromosome and whatever characters it might carry, while in the second and third cases it would be mixed. This is, however, nothing more or less than a statement of Mendel's Law.



GRIGGS on "A Cytological Life Cycle."

MEETINGS OF THE BIOLOGICAL CLUB.

Orton Hall, Feb. 17, 1913.

The Biological Club was called to order by the president, Mr. Stover. In the absence of a quorum, the business meeting was omitted.

"In his "Notes on a recent European trip," Prof. Lazenby discussed forestry and horticulture as he saw them in Germany and France. Germany's care of her forests is the result of a great fuel famine many years ago from which much suffering resulted. Each province regulates its own forest preservation, and in some cases great forests are owned and controlled by cities. Considerable amounts of money are often realized from the wood. There are many important forestry schools. Some experiments are being performed on American trees. Smoke and game are among the obstacles that the forest owners must combat. Grafting is not used as a means of propapating trees.

The next paper was a discussion of the Alfalfa Weevil, by Herbert Osborn, Jr. This insect has caused very little trouble in Europe, but is of considerable importance here. Eggs are laid in the stems of the plants and the larvae eat the tops. Two fungi and one native insect attack the weevil, but the best method of combatting it is careful cultivation of crops.

After the reading of this paper, the meeting was adjourned.

Marie F. McLellan, Secretary.

Orton Hall, March 3, 1913.

The meeting was called to order by the president, Mr. Stover, and the minutes of the two previous meetings were read and approved.

The first paper of the evening was by Prof. Robert Griggs on "A Botanical Survey of the Sugar Grove Area." Prof. Griggs first outlined the geography of the region and its geological formation, the latter being characterized by Black Hand sandstone. The rough typography is particularly interesting, caves and waterfalls being numerous. He divided the plants into three principal groups, the rock-growing plants, which are largely accidental; those on the bottom lands, which consist of a birch bottom land association with hemlocks growing up on the sides of the hills; and upland forms which are mostly pines. Many plants here

are on the edges of their ranges. On the economic side the region is spoiled by deforestation, which is causing the country to grow rapidly poorer and poorer.

The second paper was by Mr. C. R. Schroyer on "Pre-Glacial Drainage in Ohio." At the present day there are two great axes of drainage in Ohio, the Great Lakes and the Ohio River. The lines of pre-glacial drainage in at least one-half of Southern Ohio were opposite to what they are now, and in Northern Ohio the drainage was exactly reversed, the water passing out by the Maumee into northern Indiana. The old, unoccupied valleys of the Scioto basin are wide, while the new valleys are deep.

MARIE F. MCLELLAN, Secretary.

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THE MOSAIC DISEASE OF THE TOMATO AND RELATED PLANTS.*

LEO E. MELCHERS.

INTRODUCTION AND HISTORICAL SUMMARY.

The mosaic disease or calico of Solanaceous plants seems to be one of those pathological problems, which has resisted the efforts of the scientist and baffled the most observant layman for the last half century. That progress has been made in the study of mosaic disease is obvious, but the great problem of its cause still remains to be solved. In the review of its literature, it will be noticed that contradictory and conflicting results and conclusions have been so numerous, in the scientific investigations of this problem, that one cannot accept the results unconditionally. In order to summarize the results, conclusions and theories of past investigators, and to make the literature pertaining to this disease more accessible, the writer has endeavored to present a review and bibliography of the essential literature of mosaic disease. It is hoped that this will provide a reliable basis for future work.

The first reference to the disease according to Hunger (1905, p. 256), was by Swieten (1857), who mentions a disease which resembles the mosaic disease of tobacco. This disease was called "Rost" or Fleckenkrankheit (Spot disease), terms by which mosaic disease was known for some time. In 1885, Adolf Mayer investigated this disease on tobacco and in the following year published an account of it, naming it "Mosaic Disease." Koning (1899, p. 65), states that Dr. van Breda de Haan, called his

*Contributions from the Botanical Laboratory of Ohio State University. No. 74.

attention to this tobacco trouble, stating that it had occurred in the East Indies in 1888. The next investigator of this problem whose work attracted attention, was Iwanowski (1892, 1899, 1903), who most emphatically pronounced mosaic disease to be bacterial in nature. Prillieux and Delacroix (1894), describe the disease, believing that it is similar in nature to a spot disease occurring on Cyclamen. Marchal (1897), mentions mosaic disease and its treatment. Koning (1897), describes specific organisms which are supposed to be associated with this disease. Beyerinck (1898), and Sturgis (1899), both published papers. The former author propounded the "contagium vivium fluidum" theory, while Sturgis regarded it as a physiological trouble. The following year (1900), Sturgis published the results of experiments in shading and liming tobacco plants. Woods (1899) presented his paper on the destruction of chlorophyll by oxidizing enzymes, with special reference to mosaic disease. According to Hunger (1905, p. 262), Dr. van Breda de Haan (1899), isolated bacteria from the tissues of diseased plants, said to be affected with mosaic. In (1900) Heintzel published a paper on tobacco mosaic and Behrens mentioned a disease of the tobacco which resembled mosaic in its symptoms and characteristics. Gontiere (1900), in a short review gives recommendations for treating seed and seed-beds. Woods (1902) revolutionized the interpretations of this malady, by propounding his enzyme theory and Hunger (1902, 1904), believed that he had eliminated bacteria as the causal organism. But nevertheless in the following year, Hunger (1903) (a) severely criticised Woods' enzymic theory. Suzuki (1903) studied a peculiar variegation of the leaves of the mulberry, obtaining results similar to those of Woods' on tobacco. Hunger (1903) (b) published other work explaining some of the ways in which this disease is spread. In the same year Boyugues (1903), cites definite data, dealing with the incubation of mosaic disease; he also seems to have made an anatomical study of the trouble. That laborers are responsible for the spreading of this disease in part, is shown by Hunger (1903). Selby (1904) confirmed some of Hunger's infection experiments, showing that the disease could be disseminated by alternately touching diseased and healthy plants. In (1905) Hunger published a detailed treatise on mosaic disease, treating of its history, theories and experimental data. Delacroix (1905) found that a bacillus is associated with mosaic disease, and gave its exact measurements. Clinton (1908) mentions tomato chlorosis and its characteristics; he speaks of a similar malady on lima bean. Later (1910) he mentions as similar troubles, chlorosis of the squash, muskmelon and tobacco. Tomato mosaic is treated and compared with the same disease of tobacco by Westerdijk (1910). Loedwijks (1910) shows how colored light and light intensities effect the behavior of

diseased plants. Shaw (1910) believes the Curly Top of sugar beet to be a trouble pathologically and physiologically related to mosaic disease. Allard (1912) believes that Aphids are carriers of mosaic disease.

Nomenclature.—The names which have been applied to this singular disease, have been many and varied. In America, mosaic disease, calico, Frenching, mottle-top and chlorosis are terms applied in the Central States; while in the south, brindel or mongrel disease are more common. In Germany one hears of it as Mosaikkrankheit, Mauche, Fleckenkrankheit or Pockenkrankheit; in France la Mosaique, Nielle or Rouille blanche and in Hungary, Mozaik-betegsege. In Italy it is known as Mal del Mosaico or Maldella bolla and in southern Russia the name Bosuch seems to be the most used. Poetih is the name applied in Sumatra, Java and Borneo. Besides these names there are many colloquial expressions in use. Special names applied to Pockenkrankheit are: "Ospa" (Pox) in Russia; "Rjabucha" (Dot like), in Little Russia; "Pestrizi" (Spots) in S. W. Russia.

Hosts.

This disease, although originally described only on tobacco, has in recent years been found on numerous other hosts. Woods (1902) describes it as being produced artificially on the potatoes, Petunias, Violets and poke weed, and Iwanowski (1903) speaks of it as occurring on the beet and kidney bean. Similar troubles have also been found by Suzuki (1902) on the Mulberry, by Selby (1904) on cucumbers, by Clinton (1910) on lima and string beans, muskmelon and squash. Some investigators would place mosaic disease in the same class with albinism or variegation; (Woods 1899). Orton reported it on potatoes at the Cleveland meeting of the American Phytopathological Society, 1912–13, and the writer has recently found it occurring naturally on the potato in the greenhouse.

Characteristics.

Tobacco.—As already indicated above, this malady seems to be present throughout the tobacco growing regions of the world, although there are some countries growing tobacco extensively from which no reports of its occurrence have been seen.

This disease usually makes its first appearance either in the seed-bed or cold-frame. The middle or lower leaves are the first attacked and gradually the uppermost leaves show the characteristic symptoms. The disease reveals itself on the leaves by an irregular, more or less mottled effect, a differentiation into yellowish and dark green areas. The dark green areas are often confined quite largely to a border along the larger veins, while the intermediate tissue assumes a lighter green or yellowish hue. Upon closer inspection differences may be noticed; the adjoining

green regions seem slightly swollen, while the yellow areas appear appreciably thinner. Many of the affected leaves become crinkled or show an irregular growth; this is due to an uneven tissue expansion; the healthy green regions develop more rapidly than the yellow areas, hence a warping or crinkling results. Woods (1902) states that in very severe cases the entire plant may become so deformed that it is almost unrecognizable.

As the plant becomes older and the flower buds form, there may appear what is known as "mottle top," although the plant may have remained perfectly healthy up till flowering time. According to Sturgis (1899), weather conditions may bring on the disease at this time and affected plants may recover if conditions become favorable again. He regards "mottle top" as a later stage and milder form of calico; the typical mosaic appearing only in the earlier stages of plant development. The writer has occasionally encountered this in the field and from his observation it does not seem serious, as it apparently involves only a few of the uppermost leaves, which are always removed at topping time.

Tomato.- Where tomatoes are forced under glass, mosaic disease is not uncommon and appearances similar to mosaic are also found in the field. One of the first investigators to call our attention to the mosaic disease on tomato was Sturgis (1899). He cites a case where a field of tomatoes was overtaken by an early frost and severely nipped. As a result of this artificial pruning, the disease made its appearance. Woods (1902) produced the disease at will on tomato and poke weed by severely pruning healthy plants. See his plates 2, 5 and 6. Tomato chlorosis and its infectious properties are discussed by Clinton (1908). Hunger (1905) seems to be the first foreign investigator who worked with tomato mosaic. He confirmed Woods' (1902) pruning results, having used plants grown from seed from various countries. Westerdijk (1910) carried out extensive experiments with tomato mosaic, which show the disease is inheritable. According to her the disease is conspicuous on stalks and fruit as well as leaves. She says that the stalks frequently show a spiral band of yellow color. During the earlier stages of fruit development, while it is still green she says, that the yellow spots are easily recognized, but as the fruit matures, the deep red masks them.

The yellow areas on the leaves, as for tobacco, seem confined more or less to the tissues between the main veins. The dark green regions nearby seem to assume a rather "over healthy" aspect. Here again, an unequal growth of tissues cause the leaf to warp or curl. In severe cases, descriptively termed, "fern leaf" appears. Here the main veins are considerably hypertrophied, while the intermediate tissues altogether fail of development, giving the leaf a very striking dissected appearance.

Westerdijk (1910, p 7) states, "a great share of the blossoms perish before fertilization is effective; either the flowers blight or drop off." She also states that diseased plants bear less fruit than normal and that the fruit which does set is usually small or malformed. This would naturally be expected where there is an apparent lack of proper nutrition, brought about perhaps by a reduction in the assimilative and digestive powers of the leaves.

It often happens that some of the lower leaves of tomato plants show yellow spots or are entirely yellow; this in most cases is due to improper light or soil conditions and should not be mistaken for mosaic disease.

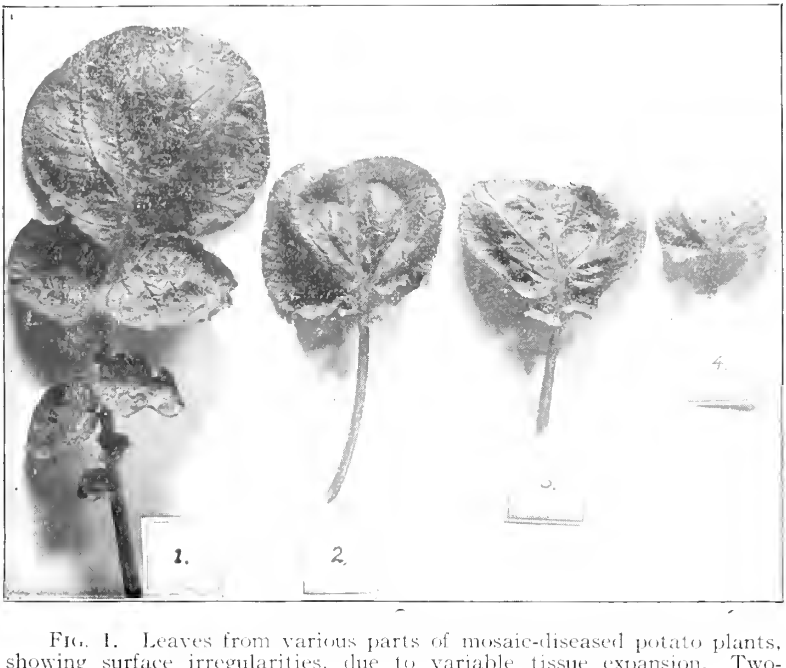

FIG. 1. Leaves from various parts of mosaic-diseased potato plants, showing surface irregularities, due to variable tissue expansion. Two-thirds natural size.

Where tomatoes are grown under glass, the extent of damage caused by this disease may vary from the injuring of a few scattered plants to the loss of a considerable share of the crop. In Ohio mosaic disease frequently appears in one or more of the main crops.

Potato.—During the month of February, 1913, mosaic disease appeared very suddenly in the Ohio State University greenhouse, on Early Lunch potatoes, which had been planted in sand for

the purpose of growing plants for breeding experiments. The writer has found no extensive description of mosaic disease on the potato in the literature, but it was reported by Orton (1913) as occurring in Germany and Maine.

The first symptoms were noticed on a plant which had reached a height of approximately eighteen inches. When first observed the plant appeared thrifty in every respect, except that the immature leaves had a slightly pale and mottled appearance. Four days later the yellowish spots were more pronounced and appeared on about two-thirds of the leaflets. The very youngest leaves were also conspicuously pale, with a sickly yellow color. In this early stage the mottled effect is not perceptible, but it becomes noticeable as the leaflets age. Those having practically reached their full development, occasionally showed a slight abnormality in shape or an uneven surface. See text Fig. 1. The mottled effect consists of irregular, greenish-yellow or pale yellow spots, which appear at any place on the leaf. See plate VII. As in tobacco and tomato mosaic, the yellow spots are localized in the tissue between the veins, which have a conspicuous border of dark green tissue. If such leaflets are sprinkled or submerged in water, the color differentiation is greatly intensified. In the majority of leaflets the green areas developed more rapidly than the yellow as usual in this disease. Such differences in growth cause a somewhat irregular surface.

Upon examination, it is to be observed that the hairs on the upper surface of the leaf are much closer together in the yellow areas than in the normal or in the green areas. It appears that the hairs develop as usual while the leaf is very young, but that there is less than the normal expansion of the leaf surface between them, so that they are left standing close together, giving the leaf a striking and peculiar appearance. The surface of a calicoed leaflet when examined under a hand lens, shows that the dark green areas are somewhat elevated, while the yellow areas are slightly depressed, giving the surface an uneven appearance. No peculiarities could be seen upon the stalks or petioles and hypertrophies were lacking. The disease appeared spontaneously without pruning or other mutilation or artificial stimulation, which is said to be sometimes responsible for the production of such deformities in the potato (Woods 1902), as well as in other hosts. The writer has not observed this trouble on potatoes growing in the field, but intends conducting experiments later. It might be stated that the tubers which produced these diseased plants came from New York.

Histology.

Koning (1899 [b], 1900) made histological studies of mosaiced leaves, but says that little is brought to light by microscopic examinations. Intercellular cavities occur between the palisade and spongy parenchyma of young and old tissue. In some cases he found the chloroplasts disorganized and cell walls disappearing. Bouygues (1903) reported the absence of the epidermis. In old spots the cell contents had disappeared. Woods (1900, p. 17) found that, "a study of the histology of the diseased leaves has now revealed a histological difference which makes it very clear that the light colored areas are not normal and that this difference consists in the fact that in badly diseased plants the palisade parenchyma of the light colored areas is not developed at all. All of the tissue between the upper and lower epidermis consists of a spongy or respiratory parenchyma rather more closely packed than normal. In moderately diseased plants the palisade parenchyma of the light area is greatly modified. Normally the palisade parenchyma cells of a healthy plant are from four to six times as long as broad. In a moderately diseased plant, however, the cells are nearly as broad as they are long, or at most not more than twice as long as broad. As a rule the modified cells of the leaf pass abruptly into the normal cells of the green area." He also found that the light colored areas in both tomato and tobacco contained more than the normal amount of starch. Heintzel (1900), does not mention any peculiarities in the palisade cells themselves, but observed the most striking differences in the intercellular spaces between the palisade cells and the spongy parenchyma of younger and older tissue. These intercellular spaces occur in the dark green, bloated regions, the older tissue having the larger spaces. He believed these spaces were filled with gas, because their dark color disappeared when they were put in alcohol. The chloroplasts were congregated irregularly in small groups. Iwanowski (1903) states that the green areas bordering the yellow are 'abnormally healthy' and that such regions show a vigorous development of all cellular tissue. The yellow areas on the other hand, are thinner and the palisade cells are not so well developed, being very much shortened and cuboidal in form. He speaks of intercellular spaces in the yellow areas. The chloroplasts in these areas are yellowish and while these regions are young, scarcely react to the starch test, but eventually all the chloroplasts come to contain as much starch as they can hold.

Tomato.—Westerdijk (1910) says that a microscopic examination of mosaiced tomato leaves show nothing worthy of mention. In the yellow areas the chloroplasts are yellowish and slightly smaller and have but little starch. The writer also made his-

tological studies of mosaiced tomato, but did not find any characteristic abnormalities. No striking differentiation was seen between the yellow and adjoining green or healthy tissues. I did not find stages as described by Woods (1900), where the palisade parenchyma was undeveloped or the presence of conspicuous cuboidal palisade cells as described by Iwanowski (1903) for tobacco. Although at times in the yellow areas this tissue appeared slightly less developed then usual. The yellow areas were slightly thinner than the adjacent green areas, especially in older leaves. The epidermis appeared normal. No difference was detected in the number or size of the chloroplasts in the yellow and green areas. That they were well supplied with starch was apparent from the slides and especially in the sections from the older tissue.

Potato.—Sections of yellow, adjoining green and healthy tissue of potato mosaic, were fixed in weak chromacetic fluid and imbedded in the usual manner. A microscopic study showed that the yellow areas were thinner at all ages; in some cases they were only 90 mic. thick as compared with 120 mic. in the normal leaf. (See Fig. 1, 2, pl. VIII.) This thinness was largely due to a shortening of the palisade cells which were of a striking cuboidal form (Fig. 1, pl. VIII). Sections from mottled areas were easily distinguished by the shape and size of the palisade cells. The cuboidal cells began very abruptly in some sections, while in other cases there was an intergradation between them and the normal palisade cells. In the yellow areas as a rule, these cells were generally quite regular in shape, but sometimes there was less regularity. Their length varied from one-half to one-third that of normal cells and their thickness was usually slightly greater. The spongy parenchyma appeared normal in all areas, except that in the yellow regions, there were somewhat fewer chloroplasts. Figure 3, pl. VIII, represents a green area, adjoining a yellow spot. The palisade cells are slightly shorter than in Fig. 2. The chloroplasts throughout the yellow regions in living material were a pale yellowish-green, but contained considerable starch.

Characteristics of Mosaic Disease.

Infectious.—Investigators who have conducted inoculation experiments with this disease on tobacco find it transmissible by means of the juice. Mayer (1886), Sturgis (1899), Hunger (1905) and others, have shown that it must be classed as infectious rather than contagious, for the mere presence of a diseased plant in a healthy plot does not cause the disease to spread. Numerous investigators have inserted diseased leaf tissue into healthy plants and produced the disease; in grafting healthy and diseased plants, similar results were obtained, Iwanowski (1903), Woods (1902) and Hunger (1904, 1905). Heintzel (1900) states, that he got

positive results by inoculating with healthy as well as diseased tissue. The same results were obtained by Woods (1899, 1902). When an excess of virus is used, this disease on tobacco according to Beyerinck (1898), developes hypertrophies. Heintzel (1902) finds that the injection of small quantities of fluid from a diseased plant produced the mottled effect, while a large amount produced hypertrophies.

Disease Spread by Contact.—Some experimenters have transmitted this disease under field conditions by touching alternately diseased and healthy tobacco plants. Koning (1899) believes that mosaic disease is spread in the field by handling plants. Hunger (1903, 1904, 1905, p. 286), in his 'touching experiments' was successful in spreading this disease and "he believes that much of the disease as it appears is due to negligence on the part of the laborers in the field." Selby (1904), as stated above, confirmed Hunger's experiments, producing the disease in the same manner by touching. Hinson and Jenkins (1910) also believe that the disease may be spread in this manner.

Spontaneous Occurrence.—Sturgis (1900) comments on the sporadic nature of this disease and states that it is not uncommon to find healthy and diseased plants growing in the same spot. Woods (1902, p. 18) says, "of the remaining twenty-five controls, four were affected with the disease without apparent cause." Iwanowski (1903), could not account for the appearance of disease in plants which had in no way been treated, 'they simply appeared spontaneously.' Hunger (1904), likewise could not account for these sudden appearances where plants had not been touched; furthermore the disease did not always appear where diseased and healthy tobacco plants were alternately touched. Westerdijk (1910), speaks of it as reoccurring periodically after it has once appeared in a greenhouse where tomatoes have been grown, although a new strain of seed was used each season.

Producing the Disease at Will.—Woods' (1902) experiments show this disease may be produced at will, by pruning, mechanically injuring the plant in various ways or even by injecting distilled water! Hunger (1905), confirmed Woods' pruning experiments with tomatoes of various sorts, including red and yellow, rough and smooth fruiting varieties. He failed, however, to duplicate Woods' results in tobacco. Allard (1912), says that a true infectious mosaic disease cannot be produced by pruning plants.

Cross Inoculation.—It is not possible to transfer this disease from the tobacco to the tomato or vice versa, according to Westerdijk (1910, p. 18–19). "It is not inconceivable that the virus of the tobacco ought to be transmissible to the tomato and inversely, because the plants are closely related. This, however, s not the case. Numbers of tomato plants were inoculated

under the most favorable growing conditions, with the virus from tobacco plants. The inoculations had no effect. The virus from the tomato had just as little effect upon the tobacco plant. The tomato plants withstood the injections very nicely and did not show the least signs of distortion." Clinton (1908) on the other hand states that he succeeded in producing mosaic disease on the tomato by inoculation with juice from a diseased tobacco plant, and from this tomato plant he transferred the disease back again to tobacco.

Is Mosaic Disease Inheritable?—Investigators are almost unanimous in the opinion that "calico" of tobacco is not inheritable. Woods (1902, p. 7) says, "There is no conclusive evidence that the plants from seed of diseased plants are more subject to the disease than are those from the seed of healthy plants." Iwanowski (1903) conducted inoculation experiments with crushed diseased seed. He produced the disease in this manner just as readily as where he used diseased leaves. He states (p. 15), "From such facts one would conclude that the disease must be inheritable, but experiments do not show this to be so." In regard to this characteristic of mosaic disease Sturgis (1899, pp. 247–8), says that seed from diseased plants do not give rise to "calicoed" plants. "It would seem apparent, therefore, that "calico" is not communicable through the seed. I secured from the seed bed—twenty seedlings showing "calico" and from the same bed, twenty apparently healthy seedlings. These were—set in two parallel rows in the garden—with one exception, all of these forty plants were badly calicoed within six weeks. The exception was one of the originally healthy plants—most of the plants flowered and ripened an abundance of seed. This seed was sown in flats in the greenhouse. Of the hundreds of seedlings—thus raised not a single one showed a sign of "calico" in the flats. Thirty seedlings were transplanted and set in a row in the Station garden—. All of the plants—showed great vigor and remained perfectly healthy. Meantime, from the same lot of seedlings, a dozen were sent to Mr. Ackley, who set them in a warm corner near the barn—. These also failed to show any signs of "calico."

"Tomato mosaic is an inheritable disease in contrast with tobacco mosaic." these are the conclusions of Westerdijk (1910, p. 20). She kept the seed from apparently healthy looking fruit on a diseased plant, separate from that of mottled fruits. She sprouted the seed and the seedlings were transferred to the greenhouse, test plot and garden. Proper checks were used in all cases. All plants grew equally well at first, but in two or three months a noticeable difference was seen. In the field she raised 50 plants, grown from diseased seed; the parent plants having been artificially inoculated. Also 46 were grown from diseased seed from greenhouse plants. Of the latter, 20 originated from mottled

and 26 from apparently normal fruit from diseased plants. All this second generation showed an intensive leaf reduction; the yellow spots appeared entirely inconspicuous. Variegated examples did not occur. The plants grown in the garden showed abnormal appearances all at the same age. Leaf reduction was less noticeable, although leaf apexes and side shoots were somewhat abnormally developed. A pronounced case of disease did not occur. In the greenhouse, the plants showed indefinite cases of mosaic disease. One plant out of 27 had strong symptoms of leaf reduction. She states (p. 17), "By the field experiments it has been shown without a doubt that the disease is inheritable. Also here it is shown that the light factor is important in developing the disease."

Resistance and Selection.—Hunger (1905) believes through proper selection a resistant strain of tobacco can be obtained. (p. 297). "On page 282 it was shown how diversely plants may develop from Deli seed, even when of the same variety, and I am convinced that it is possible, through proper selection of such seed to isolate and obtain constant physiological strains whose peculiarities would remain fixed within certain limits of temperature." Bouygeres and Perreau (1904) claim to have reduced mosaic disease 98% in a season by selecting seed from a plant which remained healthy among a diseased lot.

Various Names for Same Disease.

Considerable confusion and dispute exists among European investigators, as to whether Pockenkrankheit, Fleckenkrankheit (Spot disease) and mosaic disease, are the same or different. Mayer (1886) describes the Mosaikkrankheit, in its second stage by saying that the yellow areas gradually become brown and eventually dry up. These are also the views held by Prillieux and Delacroix (1894); and Marchal, Gontiere and Bouygues (according to Hunger 1905). This stage corresponds to the disease described as Pockenkrankheit by Iwanowski (1892) (b), who noticed it in 1888, and on account of the differences in appearance gave it the distinctive name, "Pockenkrankheit," (Pox Spot). He says (p. 68), "The Mosaic disease is contagious, but such is not the case with Pockenkrankheit. The condition producing Pockenkrankheit is excessive transpiration." He criticises (1902) Beyerinck, Koning and Heintzel for considering Pockenkrankheit and mosaic disease the same trouble. On the other hand, Delacroix (1905) assigns the name "rouille blanche," to a spotting of tobacco caused by a specific bacterium. He says "rouille blanche" must be limited to the so-called Pockenkrankheit, as named by Iwanowski. Westerdijk (1910) states that Pockenkrankheit ("necrobiotische form"), does not occur on the tomato, but that it is very common on tobacco; even more

so than the "yellow-green mosaic" which is scarcely known to many tobacco growers. Sturgis (1899, p. 258) states, "It is evident that in this so-called "spotted disease" of tobacco, we have a disease very similar to, if not identical with, that known in Connecticut as "spotting" and furthermore, that this disease is as distinct from mosaic of foreign tobacco as "spotting" is from "calico." If the statements of the Russian investigators above mentioned are correct (and there is every reason for so regarding them), "spotting" is probably due to excessive transpiration induced by sudden atmospheric changes." In regard to "spotting," in this country, he says (1899, p. 254, "It is a peculiar disease, not very common, not confined to any one locality and not characteristic of any special soil. As I have seen it—it is signalized by the presence on the leaf of small circular spots. These usually occur in the greatest numbers at or near the tips of the leaves, at first— yellow in color—irregular in outline—. The tissue within the border finally dies and becomes almost white, but except in severe cases, it does not break away from the leaf." He goes on to say that microscopic examinations have never shown the presence of fungi or bacteria. "Nothing further, therefore, can be said regarding this trouble, nor would it have been considered worthy of mention were it not for its resemblance to a disease of tobacco which occurs in Europe and Asia." Woods (1902) does not seem to mention this trouble.

There is no serious confusion in this country regarding these troubles; they seem to be distinguishable. According to Sturgis (1900), the "spotting" which may occur at times is not undesirable to a limited extent, as it enhances the value of tobacco. It is sometimes artificially produced by spraying with certain chemicals.

Causes of Mosaic Disease.

The causes which have been assigned to this disease are numerous and varied. A great many have been recklessly assigned, as often is the case when some undetermined disease has long resisted the efforts of investigators. According to Hunger (1905) it is still believed by many growers in Europe that "bad intentions" on the part of some one had much to do with its appearance. In Deli it was claimed that the disease appeared where the Coolies had urinated on the plants in the hot-bed, while in other cases laborers were accused of possessing the "warm hand."

Among recent students the cause of mosaic disease is generally considered to be due either (1) To bacterial infection, (2) The Virus theory, (3) A physiological disturbance.

1. *The Bacterial Theory.*—Here a specific organism, a bacterium, is stated to be the cause of mosaic disease. The supporters

of this theory are, Mayer (1886); Iwanowski (1892) (a) (1901, 1903); Prillieux and Delacroix (1894); Marchal (1897); Koning (1899 a, 1900 b); Breda de Haan (1899); Behrens (1896).

Mayer (1886), was perhaps one of the first to suggest bacteria as the cause, saying that the disease is of a bacterial nature. He says, however, that the organism had not been isolated and that nothing is known about its form. Breda de Haan (1899) as quoted by Hunger (1905, p. 262), claims it possible to obtain a bacterium from the plant tissues and grow it in culture. Prillieux and Delacroix (1894) state that a bacillus 0.7 mic. long was associated with grey or yellow spots occurring on tobacco leaves, which they took to be mosaic disease. Marchal (1897), speaks of finding colonies of bacteria which grew in chains and were yellow colored. He claimed that infection occurred in the seed-bed. According to Hunger (1905, pp. 259-60), however, Iwanowski was the first to find bacteria in connection with mosaic disease and certainly his work is the most complete and most convincing that has appeared in support of the bacterial theory. In (1899, p. 253) he reports, "From a poured plate in which one-half drop of mosaic diseased juice was applied, ten transfers from different colonies were made to test tubes, and from each of these, three plants were inoculated. From numbers 6 and 9, two plants showed symptoms of typical mosaic disease within 2 or 3 weeks." In a second preliminary paper (1901, p. 148), he says, "Therefore a specific bacterium is the cause of mosaic disease—." He claims that its discovery is merely a question of proper microtechnique. His final paper (1903) discussed various bacteria obtained from mosaic disease and gives photographs showing them as they occur in host cells. According to him the reason that Beyerinck was not successful in his attempts in isolating bacteria by applying juice to agar tubes, was because it was first filtered, which he says prevented growth. He states (p. 37), "One of the simplest reasons for not having been able to grow this organism from filtered juice is, that the microb is incapable of growing in pure culture and only develops in connection with other bacteria in the soil and in the living plasma of the plant." Such filtered juice, however, will produce the disease. This, he explains, by saying, that the microb forms resting spores. Upon this assumption he believed the microb could be grown only from the vegetative form. He used agar plates and succeeded in obtaining two colonies which produced mosaic disease when reinoculated. He does not mention how or where he made his inoculations and his controls do not appear to be adequate. The percentage of disease produced by his artificial inoculations was small as compared with ordinary juice inoculations; this, he explains as due to a reduction in virulence, as often is the case when bacteria are grown on artificial media.

He describes the bacterium which he used successfully for inoculation purposes, but did not make thorough studies of its habits. It is 0.3 mic. long; in fresh cultures it forms quite long threads or chains. It may liquify gelatin under certain conditions, staining it black. He concludes by saying, that the question of the artificial culture of this microbe of mosaic disease needs further study. Hunger (1905), however, reports that he succeeded at times in obtaining minute bodies which he says might be taken for bacteria. But he says (p. 264), "In fact, I was able to obtain minute bodies at times following out the technique in a few cases even the plasmodium-like bodies. Unfortunately, however, I cannot regard these as bacteria or zoogloa, since it is shown that both of these bodies disappear when phenolchloralhydrate is used in connection with heat, all remaining cell structures remain undisturbed." In a recent article, Allard (1912), believes that Aphids are carriers of mosaic disease in case of tobacco. According to his experiments, he would not place this malady in the category of purely physiological diseases. He says, that facts at hand strongly suggest the presence of a living, active microorganism.

In order to reach definite conclusions in a pathological problem of this nature, experiments must be conducted on an extensive scale. The organism should be isolated, grown on various media and its cultural characteristics properly recorded. Proper checks with inoculation experiments are absolutely necessary. An experiment without accompanying controls is of little value. The original organism must be reisolated after inoculation and its presence conclusively demonstrated in the host, before its connection with the disease can be considered established. Inasmuch as this has by no means been accomplished, the bacterial theory cannot be considered as more than a working hypothesis.

2. *The Virus Theory.*—The "contagium vivium fluidum" or virus theory seems to be a kind of variation of the bacterial theory. Beyerinck (1898) abandoned the bacterial theory and proposed this in its place. He says (p. 5), "this is not brought about by a microbe, but through a "contagium vivium fluidum." He regards the virus as a soluble substance and not a corpuscular body. It remains inert in dead organic material, but when mixed with the cell plasma, it increases in quantity, but does not lose its individuality, hence the name. He regards the Fleckenkrankheit of tobacco as a mild form of the disease, largely confined to the chloroplasts, while in the more intensive forms the protoplast as a whole is involved. His theory is based upon two considerations. (1). The virus must be a liquid and not a corpuscular body, because it diffuses through agar, which is impossible for a corpuscular body. (2). He believes that it must increase in the plant, because a small drop causes numerous

leaves and shoots to become infected. In regard to the first argument of the virus theory, we see it is not quite in accord with our present knowledge of colloidal diffusion; he eliminates a possibility. The second statement is an assumption, rather than a known fact, for the behavior of the injected juice is problematical.

Regarding the amounts of juice required for inoculation he says, (1898, p. 5), "a small drop injected into the plant at the right place will cause numerous leaves and shoots to become infected. If these diseased areas are then crushed and the juice injected into healthy plants they may become diseased." From the fact that pouring juice upon the soil causes the disease to appear first upon the youngest leaves, he concludes that the virus has a definite course in the plant. He applied juice and pieces of diseased tissue to agar plates and allowed the virus to diffuse. He carefully separated the upper and lower strata of such agar and used it for inoculation purposes and produced the disease in each case although the disease appeared more slowly when the lower strata was used. It seems strange that this author did not get a bacterial growth from such plates as Iwanowski did. Lodewijks (1910) hypothesizes a virus in these diseased plants which continually disturb merismatic regions. In normal regions an antivirus is produced which helps to neutralize the virus, like a toxin and an anti-toxin. The formation of this virus and anti-virus is influenced by external conditions; when the former is produced in excess, the plant becomes mosaiced and if the anti-virus is more abundant immunity results. Westerdijk (1910) speaks of a virus in tobacco and tomato, but does not express her opinion as to their nature. She believes that the virus of tobacco is distinct from that of the tomato. She says (1910, p. 19), "There are, therefore, two different infectious substances; they affect only their respective hosts." In her histological studies she excludes organisms as a cause, saying, (p. 8), "No organisms were found, neither in the yellow nor blue-green areas."

(3). *The Physiological Theory.*—Perhaps the most varied, but generally accepted theory is the Physiological one. Some investigators explain this disease as an enzymic trouble, while others simply say that it is of a physiological nature, without mentioning any specific factor or group of factors which can be definitely correlated with it. Sturgis (1899), in his first work on tobacco mosaic states, that artificial injuries or abnormal conditions, whereby the functions of the plant are disturbed, are probable factors in producing this disease. Soil and atmospheric conditions are important agencies according to his views, and he says that mosaic disease is more prevalent in heavy soils. Hunger (1902), believes this disease to be physiological, occurring when the plants are in a weakened condition, predisposed plants

succumbing from the effects of certain outward, injurious influences. In a later paper (1905), he states that mosaic diesase is simply due to a disturbance in the metabolism of the host. Meterological conditions, during the growing season, at least in the case of tobacco, are influential agents and the physical properties of the soil are more important than the chemical. He regards the normal tobacco plant as having mosaic disease in a latent state, or at the least being predisposed towards it, its appearance depending upon external conditions. Westerdijk (1910) says, that mosaic disease is worse in the tropics where light intensity is stronger. She shows that shading tomato plants in the greenhouse has a marked effect in controlling this malady. Heintzel (1900) also believes that this trouble can be explained from the physiological standpoint, but he restricts the cause to abnormal conditions resulting in a localized overproduction of oxidizing enzymes. He states (p. 42), "From various observations I believe, that this disease producing substance in the tobacco plant is an enzyme, or apparently enzymic in nature, which forms or is produced from or by the plant itself under certain conditions." He describes this enzyme by saying that "it is precipitated by alcohol; is soluble in water; loses its properties on boiling; but lowering the temperature even to freezing has no effect upon it; it does not increase outside of the host; salicylic acid interferes with its active properties; it retains its active properties in the dry state as well as in solution; it is diffusible, disturbs cellulose and chlorophyll; at the same time it forms a gas, oxygen." All these properties so closely relate it to an enzyme, that one can call it an enzyme without a doubt." He closes his paper by saying (p. 45), "The enzyme which causes the mosaic disease of tobacco, is therefore, known as an oxidase." Koning (1900) mentions, that he observed a peculiar dark rose color on media, whenever he placed pieces of diseased tissue on agar plates; this being more noticeable than in cases where healthy pieces were used. It appeared to him as though an oxidizing body existed. This seems to harmonize with Woods' (1899, p. 751), results, showing that peroxidases at least, are diffusible. He found that peroxidases would diffuse into agar, if small pieces of Hibiscus wood were placed upon such media.

The most detailed and convincing work in support of the enzymic theory, however, has been done by Woods (1899, 1902). He believes as Sturgis (1899) does, that soil conditions are important factors to be considered, (1902, p. 23). "Close clayey soils, packing hard after rains and requiring constant tillage are not favorable to even growth of either the top or the roots of tobacco plants." In the south poorly drained soils are said to favor the development of the disease. He is not of the opinion that a lack of soil nutrients has anything to do with its appearance.

But he states that there is evidence that rapid growth, caused by excessive nitrogenous manure or too high a temperature, is favorable to it. This latter statement seems to correspond with observations made by the writer on the appearance of some cases of tomato mosaic under glass. Woods (1902), does not explain why nitrogenous fertilizers should act in this manner; the plants are really in need of reserve nitrogenous compounds, as will be seen later. He says, however, (p 23), "It is probably connected, however, with the manufacture of reserve nitrogen by the cells and its distribution to the rapidly growing parts." He thinks that tobacco mosaic is especially liable when moist cloudy weather, stimulating rapid growth, is followed by hot, dry weather, checking growth and causing the soil to bake, so that cultivation is apt to injure the root system.

He carried out inoculation experiments along the same lines as other investigators, showing that this disease is infectious. He performed other experiments however, to prove that mosaic disease could be produced at will without employing the juice of diseased or healthy plants. He was able to produce mosaic disease on tomato plants by severally pruning them. Pot-bound tobacco plants were selected and after they had been cut back, (allowing two or three lower leaves to remain), they were submitted to high temperature and copious watering. The rapidly developing shoots became mottled and often distorted. Mosaic disease appeared in plants which were simply punctured with a steril scalped and in other cases where a piece of healthy leaf was inserted. Juice of diseased plants, boiled and double boiled when injected into the terminal bud, or poured around the roots caused the appearance of the disease. Woods (1899, p. 753) says, "It seems plausible that in rapid, poorly nourished growth many of the cells were unable to develop their normal amount of chlorophyll by reason of the excessive development of oxidizing enzymes."

Oxidizing Enzymes.—Woods states (1902, p. 23), "The disease is not due to parasites of any kind, but is the result of defective nutrition of the young dividing and rapidly growing cells, due to a lack of elaborated nitrogenous reserve food accompanied by an abnormal increase in activity of oxidizing enzyme in the diseased cells." According to Woods (1902), this excess of oxidases in turn inhibits diastatic activity so that starch accumulates in diseased cells in abnormal quantities. The resulting imperfect translocation may be demonstrated by the application of iodine at different hours during a day. By this means a striking difference between the normal and the abnormal tissue may be demonstrated. Suzuki (1902) arrives at similar conclusions, in the study of his mulberry disease; he confirmed Woods' experiments, showing that it was brought on by excessive pruning and that there was an

overproduction of oxidases in the varigated leaves. He says (1902, p. 277). "The formation of oxidases and peroxidases in abnormal quantities is a peculiar symptom of this disease and at the same time one notices that the translocation of starch and nitrogen compounds is noticeably delayed, so that appreciable quantities of starch are accumulated." He (1902) confirmed Woods' (1899, 1902), experiment on the inhibiting effect of oxidases on diastatic action. Hunger (1903, 1905) and Shibata (1905) were not able, however, to confirm Woods' work and Hunger criticises this theory, believing that Woods worked with impure enzyme solutions and that it was not the oxidase, but rather the tannin which interfered with the diastatic action. Woods (1899, p. 749), however, had shown that diastatic action is hindered even if tannin is removed so that the retardation must be due to the oxidases present. He is not certain that the inhibiting action is as marked during warm weather and under natural conditions. One would naturally expect that such an interference would hinder the production of sugars and proteid compounds. It is on account of of this Woods (1902) believes, that cells of the diseased areas are very poor in reserve nitrogen. Suzuki's (1902) chemical analysis shows this to be the case with the mulberry disease.

Woods (1899, p. 750) finds that "peroxidase is always more than twice as strong in the light colored areas as in the green." In albino spots he found the oxidase twice as strong as in the green areas of the same leaf or in healthy leaves." (p. 753). "It has been suggested by Dr. Loew that partial starvation may cause the increase of these enzymes in a cell, and it has been shown by Brown and Morris, that starvation causes an increase of diastase in the cells of various plants." These enzymes occur throughout the plant according to his statements and when diseased plants disintegrate the enzymes enter the soil and may later be taken up by other plants. Heintzel (1900) and others are also of the opinion that the disease may be disseminated in this way.

Woods (1902) is not able to explain the infectious nature of this disease in accord with the facts, unless the oxidizing enzymes artificially introduced into the plant have the power of evolving these changes. He believes that a zymogen exists for these enzymes. By boiling juice from diseased plants he apparently destroyed the oxidizing enzymes which preliminary tests had shown to be present. After this same juice had been allowed to stand for a day, further tests gave a strong reaction for oxidases. A second boiling after four hours was not followed by a regeneration of the enzymes. He concludes, therefore, that the zymogen exists in the cells in sufficient quantities to regenerate practically the original amount of active enzyme. He believes that as soon as the active enzyme is removed or destroyed, it is regenerated by the zymogen. The protoplasm is not supposed to regulate the

relation between the active and reserve enzyme, for the regeneration occurs in dead cells; no new supply of zymogen is manufactured, neither in the expressed juice nor in the functionless or dead cells.

Although Woods' theory attempted to explain the behavior of these enzymes, his views are not now quite in accord with the rapidly changing ideas concerning this class of enzymes. He does not attempt to explain their mode of action upon inoculation in the host. No statements are made as to the means by which a minute drop of juice injected in the proper place brings about such transformations as are observed in mosaic disease. It is well known that zymogens exist for enzyme processes in which hydrolytic actions occur. Starling (1902) has shown that trypsin of the pancreatic juice is actually secreted as a zymogen, trypsinogen, which lacks proteoclastic power, but possesses other properties similar to those of trypsin itself. The oxidizing enzymes seem to be far more complex and the intimate and intricate mechanism of this group is not so well understood. There seems to be no satisfactory explanation of the increased abundance of oxidizing enzymes in diseased areas of leaves. The methods employed by Woods (1899) for determining the presence of these oxidases were simply colormetric tests, since the reactions accelerated by the juice involve a change in color. Various indicators were used, of which tincuture of guaiacum was most satisfactory. He designated those enzymes which gave a reaction directly with guaiacum, as oxidases, those requiring an addition of hydrogen peroxide, peroxidases. This classification is no longer used, see Bayliss (1911, p. 109). Woods' tests were simply qualitative and cannot be depended upon for various reasons as Foa (1908) points out. Guaiac resin for example, assumes a blue color on oxidation, but loses it when the process of oxidation is continued beyond a certain stage. He also gives one to understand that oxidases and peroxidases are not always constant in their mode of action. A certain result in the oxidation of any particular substance gives no ground for generalization as to the catylitic power in general.

Up to the present time no manometric analysis of plants affected with mosaic disease seems to have been made. Such methods have been devised and employed by Mathews (1909) in the Spontaneous Oxidation of Sugars and Bunzel (1912, 1913) on the curly-top of beets. It is obvious that such an analysis would bring out the exact relationships which exists between these enzymes, in healthy and diseased leaves or in any specific areas of such leaves.

Preventive Measures.

Various measures have been suggested by scientists and growers for the purpose of controlling or preventing the appearance of mosaic disease. Most of the remedies for tobacco mosaic are

based upon soil treatment or reduction of light intensity. Mayer, as early as 1886, showed that renewing soil in the hot-bed gave wonderful results in reducing the disease. By proper liming and shading, Sturgis (1899, 1900), showed that tobacco could be grown practically free from mosaic disease, on soils where calico had been prevalent. Koning (1899) regarded the use of lime and mineral fertilizers as valuable aids to the production of a healthy crop. Loew (1900, p. 25) says, "Some planters entertain the belief that a too extensive use of mineral fertilizers favors the disease and indeed, those fields had the least number of diseased plants which had received chiefly organic manure." The use of new soils for seed-beds and a seed treatment with copper sulphate, is proposed by Gontiere (1900). Eliminating root injury in all ways; preventing too rapid a growth due to using an excess of nitrogenous fertilizer and avoiding improperly drained soils, are Woods' (1902) ideas for combatting the disease. Hunger (1903, 1904, 1905) believes that diseased plants and roots tide the disease over from year to year, and recommends that they should be removed from the fields. He regards the avoidance of all injuries to plants important. Bouygeres and Perreau (1905) advise the elimination of manures. Hinson and Jenkins (1910, p. 10) say, "So far the only known methods of lessening "calico" in the seed-bed, are avoiding the use of tobacco water, as noted before, and the probable good resulting from steam sterilization." Different light intensities and the use of colored lights are possible factors influencing this disease, according to Lodweijks (1911).

The prevention of tomato mosaic under glass is discussed by Westerdijk (1910). She states (pp. 6-7), "The grower can reduce this disease by white-washing the greenhouse as soon as the first signs of yellow spots are noticed." As mentioned before, the writer has observed that over forcing is liable to cause its appearance in the greenhouse.

Other Plant Diseases Apparently of an Enzymic Nature.

Besides the work of Woods (1899, 1902), Heintzel (1900) and Hunger (1903) on tobacco mosaic and Suzuki (1902) on the Mulberry disease, mentioned above, there are several more recent investigations which take up certain pathological problems from the standpoint of the enzymic disturbances involved. Pozzi-Escot (1905) assigns various maladies to an over abundance of oxidases. It is believed that a counter action takes place between these and beneficial enzymes which are active in metabolism. Sorauer (1908), in making a study of the leaf curl of potatoes, found that no specific organism was connected with this trouble, but an enzymic disturbance did present itself. In comparing the diseased and healthy tubers, he found great differences in enzymic reactions. Appel and Schlumberger (1911) have considered this

problem from an etiological standpoint. Curly-Top of sugar beets has been an exceedingly baffling disease. Not until (1908) did investigators grasp the situation and the cause was not discovered until (1910). In this year Shaw proved it to be due to an active agent introduced by the bite of the beet leaf hopper. In (1912) Bunzel devised his apparatus for measuring the oxidase content of plant juices quantitatively, and applied it in determining the oxidase content of curly-top of beets in 1913, showing that the leaves of curly-top plants have an oxidase content two or three times that of healthy leaves. During the past year the writer has made a study of an apparently similar disease of the Raspberry, known as Raspberry Yellows or Curl, which although never previously reported, has occurred quite abundantly in Ohio for the last seven years. In addition to these, Peach Yellows, Little Peach, Peach Rosette and other plant diseases have often been regarded as enzymic diseases, but the writer knows of no detailed investigations of the enzymes supposedly concerned.

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EXPLANATION OF PLATES.

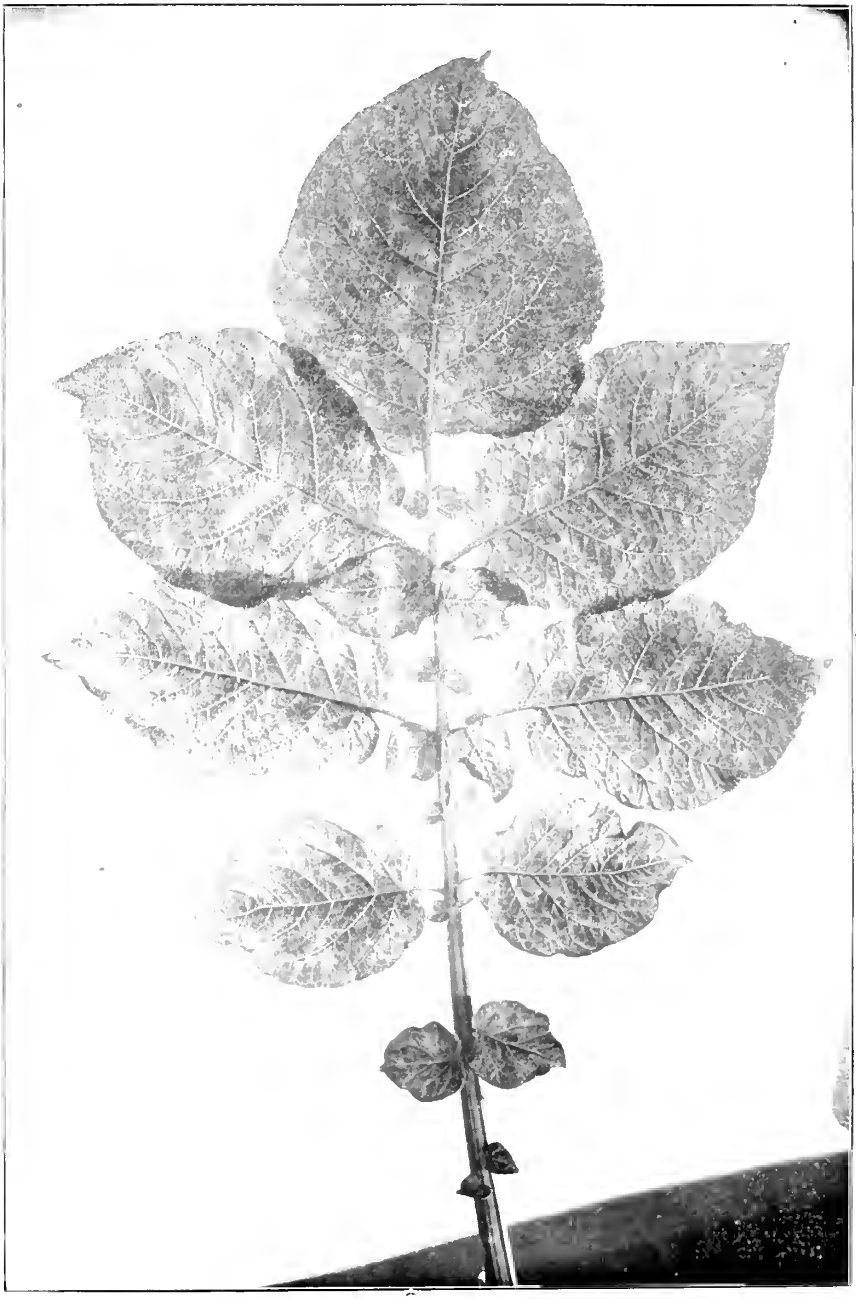
Plate VII.

A photograph of leaf showing the mottled effect; the light spots were the yellow areas between the veins. Transmitted light was employed in securing this photograph.

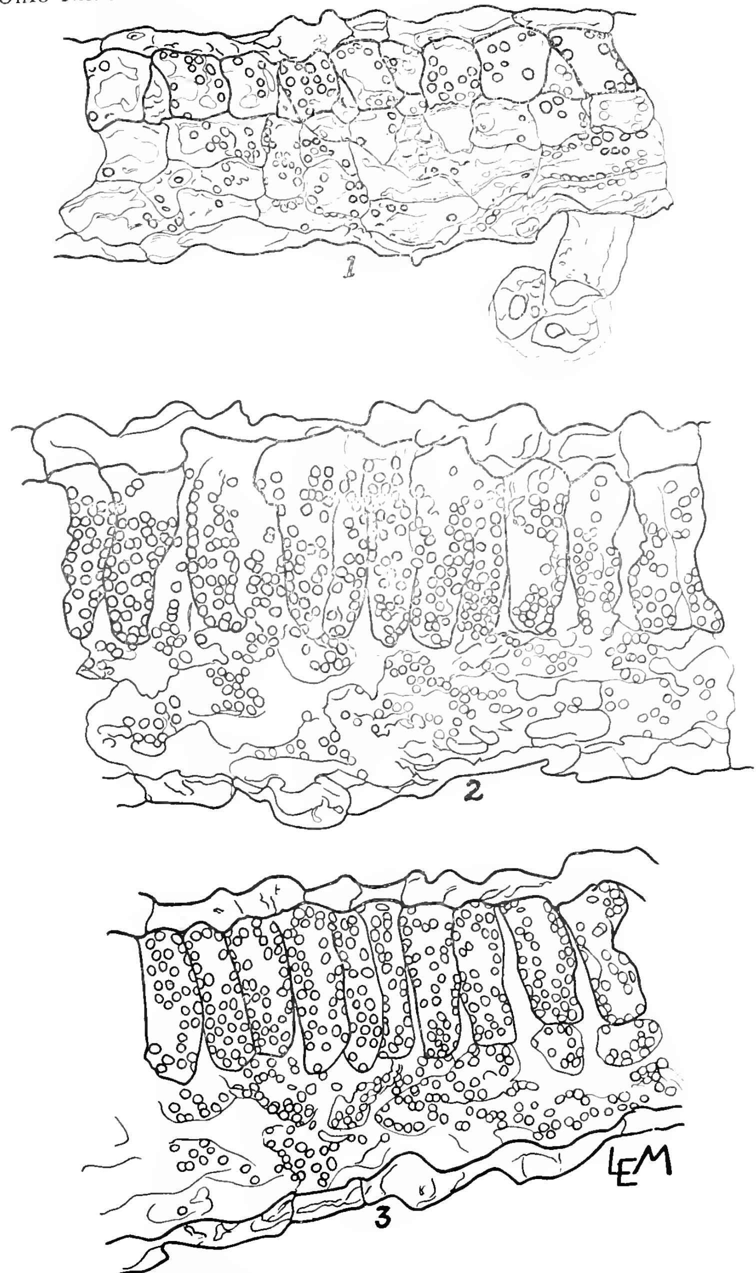
Plate VIII.

The figures were drawn with the aid of a camera. A one inch ocular and 4mm. objective were used in each case. The figures have been reduced one-half. Matured tissues of the same age were selected for making the drawings.

Fig. 1. A yellow area showing the cuboidal palisade cells.
Fig. 2. Section from a healthy leaf.
Fig. 3. Section from a green area adjoining a yellow spot.



MELCHERS on "The Mosaic Disease of the Tomato and Related Plants."



Melchers on "The Mosaic Disease of the Tomato and Related Plants."

CARYOPHYLLACEAE OF OHIO.

Amy Williams.

Herbs often with swollen nodes, with opposite entire leaves, and hypogynous, bisporangiate or rarely monosporangiate, regular flowers. Sepals 4 or 5, persistent, separate or united into a calyx-tube; petals equal in number to the sepals or occasionally none; stamens twice as many as the sepals or fewer; anthers longitudinally dehiscent; ovulary usually unilocular with a central placenta, bearing several to many seeds; fruit usually a membranous capsule dehiscent by valves or teeth.

Synopsis.

I. Calyx of distinct sepals, or the sepals united only at the base. Petals without claws. Ovulary sessile. *Alsinatæ.*
   1. Stipules wanting.
      a. Petals entire, toothed, or slightly notched. Sagina, Arenaria, Mœhringia, Holosteum.
      b. Petals 2-cleft. Alsine, Cerastium.
   2. Stipules present. Spergula, Tissa.

II. Calyx of united sepals, tubular or ovoid. Petals with slender claws. Ovulary stalked. *Caryophyllatæ.*
   1. Calyx ribs at least twice as many as the teeth. Agrostemma, Lychnis, Silene.
   2. Calyx 5-ribbed or 5-nerved or nerveless. Saponaria Vaccaria, Dianthus.

Key to the Genera.

1. Calyx of distinct sepals or united only at the base. 2.
1. Calyx of united sepals, tubular or ovoid. 9.
2. Stipules none. 4.
2. Stipules present, scarious. 3.
3. Styles and capsule valves 5; pod short. *Spergula.*
3. Styles and capsule valves 3. *Tissa.*
4. Petals deeply 2-cleft or 2-parted, (rarely none). 5.
4. Petals entire or emarginate (rarely none) 6.
5. Styles 4 or 5; pod cylindrical; dehiscent by twice as many equal teeth as styles. *Cerastium.*
5. Styles usually 3, rarely 5; pod short, splitting into as many valves as styles; valves often 2-parted. *Alsine.*
6. Styles 4 or 5, alternate with the sepals; pod short. *Sagina.*
6. Styles usually 3. 7.
7. Stamens 3 to 5; capsule cylindric; flowers cymose-umbellate; annual. *Holosteum.*
7. Stamens 8 to 10; capsule ovoid or oblong. 8.
8. Leaves 1 to 1½ inches long, oblong or oval; seeds strophiolate. *Mœhringia.*
8. Leaves less than ½ inch long or if longer, then linear or subulate; seeds not appendaged by a strophiole. *Arenaria.*
9. Calyx without scaly bractlets or small leaves at the base; styles 5 to 2. 10.
9. Calyx with scaly bractlets or small leaves at the base. *Dianthus.*
10. Styles 5 to 3. 11.
10. Styles 2. 13.
11. Styles 5. 12.
11. Styles 3, rarely 4; petals with scales at the base of the blade. *Silene.*

12. Petals unappendaged; styles opposite, alternate with the leaf-like calyx-teeth. *Agrostemma.*
12. Petals often appendaged; styles alternate with them; calyx-teeth short. *Lychnis.*
13. Petals appendaged at the base of the blade, calyx terete. *Saponaria.*
13. Petals not appendaged, calyx 5-angled, enlarged in fruit. *Vaccaria.*

Sagina L.

Low, tufted, matted herbs with subulate leaves. Flowers white; petals 4 or 5, entire, emarginate, or none: sepals 4 or 5; stamens 4 or 5 or 8 or 10; styles of the same number, arranged alternately.

1. Plant depressed-spreading; petals present. *S. procumbens.*
1. Plant erect; petals minute or none. *S. apetala.*

1. **Sagina procumbens** L. Procumbent Pearlwort. Annual or perennial; branching, decumbent or spreading; smooth or somewhat downy-matted, ½ to 2½ inches high; leaves linear, subulate, connate at the base; flowers arranged on capillary peduncles which are often reflexed in fruit; sepals and stamens 4 or rarely 5; petals sometimes absent. Lake, Gallia.

2. **Sagina apetala** Ard. Small-flowered Pearlwort. Erect or ascending, annual, glabrous, filiform, about 3½ inches high; leaves linear-subulate, smooth or slightly ciliate, ¼ inch long; flowers on long peduncles; petals none or four very minute ones; sepals 4, ovate or oval, obtuse. Lawrence County.

Arenaria L.

Tufted herbs with sessile leaves. Flowers white, in cymes, heads, or rarely solitary; petals 5; sepals 5; stamens 10; styles generally 3.

1. Plant pubescent, leaves ovate-acute, cymes leafy. *A. serpyllifolia.*
1. Plant glabrous, leaves subulate. 2.
2. Perennial; leaves in groups at the nodes or axils, rigid. *A. michauxii.*
2. Annual; leaves opposite, soft. *A. patula.*

1. **Arenaria serpyllifolia** L. Thyme-leaf Sandwort. Annual, somewhat pubescent, branched, 5½ to 14 inches high; leaves ovate, acute; flowers numerous, arranged in cymose panicles; sepals ovate, acute; petals obovate or oblong, usually shorter. General in Ohio.

2. **Arenaria michauxii** (Fenzl.) Hook. Rock Sandwort. Perennial, tufted, glabrous, dark green, 7 to 15 inches high; leaves subulate or filiform, 1-ribbed arranged in fascicles in the axils, ¾ inch long; calyx ovoid-oblong in fruit; sepals lanceolate or ovate-lanceolate, acute, one half the length of the petals. Ottawa, Erie, Cuyahoga, Clarke, Franklin.

3. **Arenaria patula** Mx. Pitcher's Sandwort. Annual, glabrous, very slender, 8 to 10 inches high; leaves soft, linear-filiform, ¾ to 1 inch long; flowers in cymes, sepals lanceolate, acuminate, about one-half the length of the emarginate petals. Montgomery County.

Moehringia L.

Low perennial herbs. Leaves oblong, ovate-lanceolate or linear, sessile or with short petioles; flowers white, solitary or in cymes; sepals and petals 4 or 5, stamens 8 or 10.

1. **Moehringia lateriflora** (L.) Fenzl. Blunt-leaf Moehringia. Stems finely pubescent, 6 to 14 inches high; leaves thin, oval or oblong, obtuse, the margins and nerves ciliate; flowers arranged in cymes or solitary; petals twice as long as the sepals. Ottawa, Auglaize, Darke. Morrow, Franklin, Perry.

Holosteum.

Annual or biennial, erect herbs with acute, ovate-lanceolate leaves. Flowers white, arranged in long terminal peduncles in umbellate cymes; petals 5, sepals 5, stamens 3 to 5, rarely 10.

1. **Holosteum umbellatum** L. Jagged Chickweed. Glabrous or somewhat glandular, 3 to 7 inches high, pubescent above and a little hairy below. Basal leaves spreading, oblanceolate or oblong; stem leaves oblong, sessile; flowers arranged 3 to 8 in an umbel; pedicels erect in flower, reflexed in fruit; sepals obtuse, shorter than the petals. Hamilton County.

Alsine L.

Tufted herbs with white flowers arranged in cymes. Sepals 5 rarely 4; petals of the same number, 2 cleft, 2 parted, or emarginate, rarely none; stamens 10 or fewer; styles usually 3, rarely 4 or 5, generally opposite the sepals.

1. Styles 5; leaves ovate, pointed. *A. aquatica.*
1. Styles 3, rarely 4. 2.
2. Leaves linear or lanceolate, not pubescent. 3.
2. Leaves ovate-pubescent. 4.
3. Leaves acute at each end; seeds smooth. *A. longifolia.*
3. Leaves broadest near the base; seeds rough. *A. graminea.*
4. Petals shorter than the calyx; lower leaves petioled. *A. media.*
4. Petals longer than the calyx; lower leaves rarely petioled. *A. pubera.*

1. **Alsine aquatica** (L.) Britt. Water Chickweed. Perennial, usually glandular-pubescent above, ascending or decumbent, about 13 inches high. Leaves ovate or ovate-lanceolate, acute; the upper ones sessile, the lower petioled, rounded at the base, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long; flowers solitary, in the forks of the stem, or in cymes; pedicels longer than the calyx in fruit, deflexed; calyx campanulate, sepals about half as long as the 2-cleft petals; stamens 10. Guernsey County.

2. **Alsine media** L. Common Chickweed. Annual; tufted and much branched, decumbent or ascending; 4 to 14 inches high; glabrous, except the line of hairs along the stem and branches, the pubescent sepals and ciliate petioles; leaves oval or ovate, usually acute; flowers in terminal, leafy cymes or solitary in the axils. General.

3. **Alsine pubera** (Mx.) Britt. Great Chickweed. Perennial; stems and branches with two lines of hairs; 3 to 12½ inches high; leaves oblong or ovate-oblong, their margins ciliate, the upper generally sessile, the lower sometimes narrowed into broad petioles; flowers in terminal cymes with lanceolate sepals and 2-cleft petals. Medina, Preble, Clermont, Fairfield, Pike, Lawrence, Gallia, Vinton.

4. **Alsine longifolia** (Muhl.) Britt. Long-leaf Stitchwort. Glabrous, ascending; stem rough angled; leaves linear, spreading, acute; flowers numerous, arranged in terminal or lateral cymes. General in northern Ohio; also in Highland, Jackson and Gallia Counties.

5. **Alsine graminea** (L.) Britt. Lesser Stitchwort. Weak, glabrous, ascending from creeping rootstocks; 6 to 12 inches high; stem 4-angled; leaves lanceolate, sessile; flowers arranged in loosely spreading cymes; bracts lanceolate sometimes scarious or ciliate; sepals equalling the 2-cleft petals. Cuyahoga, Auglaize, Belmont.

Cerastium L.

Pubescent or hirsute herbs. Flowers white, arranged in terminal cymes; petals 5, rarely 4, emarginate or bifid, (rarely wanting); sepals 4 or 5; stamens 10, rarely fewer; styles 4 or 5 or fewer, arranged opposite the sepals.

1. Leaves linear or lanceolate, 8 to 10 times as long as broad; petals longer than the sepals. 2.
1. Leaves ovate-lanceolate, about 4 times as long as wide, petals 3, equalling or shorter than the sepals. *C. vulgatum*.
2. Stem erect; pubescent, densely tufted; perennial; styles 5. *C. arvense*.
2. Stem weak, reclining or ascending, clammy-pubescent to glabrate, annual. *C. longipedunculatum*.

1. **Cerastium vulgatum** L. Common Mouse-ear Chickweed. Biennial or perennial, viscid-pubescent, 7 to 14 inches high. Lower and basal leaves spatulate-oblong; upper leaves oblong, ½ to ¾ inch long; flowers loosely arranged on long pedicels. General.

2. **Cerastium longipedunculatum** Muhl. Nodding Chickweed. Annual, reclining or ascending, 6 to 16 inches high; clammy-pubescent to glabrate. Lower leaves spatulate, obtuse, petioled, 1 to 1½ inches long; flowers loosely arranged, pedicels very long in fruit; petals when present about twice as long as the sepals. General in southern Ohio, also in Ottawa and Cuyahoga Counties.

3. **Cerastium arvense** L. Field Chickweed. Perennial, downy or nearly smooth, 6 to 12 inches high. Basal leaves and those on the sterile shoots linear-oblong; stem leaves distant, linear or narrowly lanceolate; petals obcordate, longer than the lanceolate acute sepals. Sandusky, Ottawa, Trumbull, Miami, Monroe.

4. **Cerastium arvense oblongifolium** (Torr) Holl. and Britt. Pubescent; leaves oblong or lanceolate; capsule about twice the length of the calyx. Erie, Monroe.

5. **Cerastium arvense webbii** Jennings. Plant more or less viscid-pubescent, 12 to 18 inches high. Lower leaves oblong-lanceolate, upper ones ovate-lanceolate, 1¾ to 2 inches long; flowers arranged in strict cymes. Cuyahoga.

Spergula L.

Annual herbs. Leaves subulate, stipulate, arranged in fascicles in the axils; flowers white, in terminal cymes; sepals 5; petals 5; stamens 10 or 5; styles 5, alternate with the sepals.

1. **Spergula arvensis** L. Corn Spurry. Glabrous or finely pubescent, 9 or 10 inches high. Leaves linear or subulate; stipules small, connate; pedicels slender, divaricate. Lake County.

Tissa Adans.

Low herbs with fleshy, linear, or setaceous leaves; often arranged in fascicles in the axils; stipules scarious; flowers pink or white in terminal cymes; sepals 5, petals 5, rarely fewer or none, entire, stamens 2 to 10.

1. **Tissa rubra** (L) Britt. Sand-spurry. Annual or perennial, depressed or ascending, leafy, glabrous or glandular-pubescent above; 5 to 7½ inches high; leaves linear, ¼ inch long; flowers bright pink; stipules ovate-lanceolate, acuminate; sepals ovate-lanceolate, somewhat acute. Lake County.

Agrostemma L.

Annual or biennial, pubescent or wooly herbs. Leaves opposite, linear or linear-lanceolate, acute or acuminate, sessile; flowers red or white, solitary; petals 5, shorter than the sepals, unappendaged, emarginate; calyx oblong, wooly, 10-ribbed; sepals 5, linear, elongated and foliaceous, stamens 10, styles 5, opposite the petals.

1. **Agrostemma githago** L. Corn Cockle. Plant erect, 12 to 40 inches high, covered with long, whitish, appressed hairs; leaves linear-lanceolate; calyx ovoid, sepals exceeding the petals and deciduous in fruit; flowers red, petals slightly emarginate, obovate-cuneate. General.

Lychnis L.

Mostly more or less pubescent herbs. Sepals 5, petals 5, entire, 2-cleft or laciniate, generally crowned; stamens 10; styles 5, rarely 4; calyx ovoid, tubular or inflated, 10-nerved.

1. Plant entirely pubescent, viscid. 2.
1. Plant having viscid-pubescent bands on the stems. *L. viscaria.*
2. Calyx-teeth twisted; plant densely white-wooly. *L. coronaria.*
2. Calyx teeth not twisted; only ordinarily pubescent; usually diecious. 3.
3. Flowers white or pink; calyx teeth attenuate. *L. alba.*
3. Flowers red; calyx teeth triangular-lanceolate, acute. *L. dioica.*

1. **Lychnis coronaria** (L) Desv. Mullein Pink. Perennial, wooly white, quite tall. Lower leaves spatulate; upper leaves oblong or lanceolate, sessile, acute or acuminate; flowers few in terminal panicles; petals crimson; calyx oblong-campanulate, its teeth twisted and shorter than the tube. Cuyahoga, Portage, Lake, Fairfield.

2. **Lychnis viscaria** L. Viscid Lychnis. Plant erect. Lower leaves spatulate; upper ones linear or linear-lanceolate; inflorescence in oppositely arranged clusters; calyx club-shaped. Escaped in Lake County.

3. **Lychnis alba** Mill. White Lychnis. Biennial and branched with leaves ovate-oblong or ovate-lanceolate, acute; upper ones sessile, the lower ones having petioles; flowers few, arranged in loose panicles, white or pink, fragrant; calyx at first tubular, becoming inflated by the ripening pod; sepals lanceolate, short; petals obovate, 2-cleft, crowned. Lake, Meigs.

4. **Lychnis dioica** L. Red Lychnis. Biennial. Basal leaves with long petioles, oblong; stem leaves sessile or the lower short petioled, ovate, acute; flowers red or nearly white, opening in the morning, calyx at first tubular, in fruit nearly globular. Erie County, Mosely Herbarium.

Silene L.

Herbs with pink, red or white flowers; calyx more or less inflated, with 5 sepals, 10 to many nerved, not bracted at the base; stamens 10; styles 3, rarely 4 or 5; petals 5, narrow, clawed, variously cleft or rarely entire; flowers solitary or in terminal cymes.

1. Leaves verticillate in fours. *S. stellata.*
1. Leaves opposite. 2.
2. Flowers white or greenish. 3.
2. Flowers scarlet to pink. 6.
3. Calyx much inflated and bladdery, not with prominent ribs. 4.
3. Calyx tubular, merely expanded by the ripening pod, prominently ribbed. 5.
4. Inflorescence leafy bracted; flowers few. *S. alba.*
4. Flowers numerous, in leafy cymes. *S. vulgaris.*
5. Flowers racemose, short-pedicelled, calyx ribs 5. *S. dichotoma.*
5. Flowers cymose, night-blooming; calyx ribs 10. *S. noctiflora.*
6. More or less viscid-pubescent, perennial. 7.
6. Glutinous at or below the nodes, annual. 10.
7. Leaves broadly oval, the lower ones tapering into a long petiole; stems pubescent. *S. rotundifolia.*
7. Leaves lanceolate or spatulate, the blades not rounded. 8.
8. Leaves broadest below the middle, sessile; stems very rough. *S. regia*
8. Leaves, all except the uppermost, broadest above the middle, the lower ones tapering into a petiole. 9.
9. Leaves broadly spatulate. *S. virginica.*
9. Leaves narrowly spatulate or oblanceolate. *S. caroliniana.*
10. Stems pubescent, leafy; calyx much inflated, many-ribbed. *S. conica.*
10. Stems smooth. 11.
11. Clayx club-shaped, many ribbed; leaves ovate-lanceolate. *S. armeria.*
11. Calyx ovoid; leaves linear. *S. antirrhina.*

1. **Silene stellata** (L) Ait. Starry Campion. Perennial, pubescent, erect. Leaves ovate-lanceolate, verticillate in fours or the lowest ones opposite, their margins finely ciliate; flowers white, in panicled cymes, 1/2 to 3/4 inches wide; calyx campanulate, inflated, 1/4 to 1/2 inch long, its teeth triangular, acute; petals about equalling the stamens, not crowned. General.

2. **Silene alba** Muhl. White Campion. Perennial, rather weak, reclining, slightly pubescent or glabrate. Leaves lanceolate or oblong-lanceolate, opposite, 3 to 4 inches long, ½ to 1 inch broad, acuminate; flowers white, 1/2 to 1 inch broad; calyx inflated, elongated-campanulate, pubescent, with ovate teeth; petals cuneate, 2-cleft or 2-lobed, minutely crowned. Butler, Clermont.

3. **Silene vulgaris** (Moench.) Gareke. Bladder Campion. Perennial herb, branched from the base, glaucous, glabrous, or rarely pubescent. Leaves ovate-lanceolate or oblong acute, lower ones often spatulate; flowers white, in cymose panicles, sometimes drooping; petals 2-cleft; calyx inflated and globose, 1/4 to 1/2 inch long; stamens much longer than the petals and sepals. Erie County.

4. **Silene virginica** L. Fire Pink. Perennial, clammy-pubescent, 10 to 24 inches high. Stem slender; leaves thin, 3 to 5 inches long, lower ones spatulate or oblanceolate, upper ones oblong-lanceolate, acute, sessile; flowers in loose cymose panicles, crimson, petals oblong, 2-cleft, 2-lobed, or irregularly incised, crowned; calyx tubular-campanulate. General.

5. **Silene rotundifolia** Nutt. Round-leaf Catchfly. Perennial, ascending or reclining, viscid-pubescent; lower leaves spatulate or obovate, upper ones broadly oval, thin; flowers few or solitary; petals 2-cleft, lobed or laciniate, crowned, scarlet; pedicels very slender; calyx tubular-campanulate, about an inch long, somewhat enlarged by the ripening pod, it's teeth ovate, acute. Hocking, Jackson.

6. **Silene armeria** L. Sweet William Catchfly. Glabrous, glaucous or minutely puberulent, about 23 inches high. Leaves ovate-lanceolate; flowers in flat cymes with petals rose-colored, white or purple, notched and crowned with awl-shaped scales; calyx club-shaped. Cuyahoga, Lake, Licking, Monroe.

7. **Silene noctiflora** L. Night-blooming Catchfly. Annual, erect, viscid-pubescent, 8 to 32 inches high. Leaf-blades thickish, lower ones large and spatulate, upper ones lanceolate; flowers few and large, white or nearly so, fragrant and opening at night; calyx glandular-pubescent, ½ inch or a little more in length, with awl-shaped teeth. Lucas, Sandusky, Erie, Cuyahoga, Lake, Auglaize, Green, Belmont, Jefferson.

8. **Silene dichotoma** Ehrh. Forked Catchfly. Annual, pubescent. Lower and basal leaves lanceolate or oblanceolate,

acuminate or acute, tapering into a petiole; upper leaves sessile, lanceolate or linear; flowers white; calyx cylindric, hirsute, much enlarged by the ripening pod, with ovate-lanceolate, acute teeth; petals white, bifid, with a short obtuse crown. Ottawa County. Mosely Herbarium.

9. **Silene conica** L. Striate Catchfly. Annual, puberulent to tomentulose, or canescent, usually with several stems; leafy, 3 to 12 inches high. Leaves linear, lanceolate, acute, sessile; calyx ovoid, rounded or truncate at the base, strongly ribbed, about half an inch long, teeth triangular-subulate; flowers in cymes, petals rose-colored, obcordate. Sandusky County.

10. **Silene regia** Sims. Royal Catchfly. Perennial, erect and very rough, minutely pubescent. Leaves thick, ovate-lanceolate, acute, 1 to 2½ inches long, all but the lower ones sessile; flowers numerous, on short stalks and arranged in a panicle; deep scarlet; petals emarginate or laciniate, crowned; calyx oblong, tubular, slightly enlarged by the ripening pod. Clarke, Madison.

11. **Silene caroliniana** Walt. Carolina Catchfly. Perennial, viscid-pubescent, 8 to 10 inches high, basal leaves spatulate, nearly glabrous, tapering into broad, pubescent petioles; stem leaves sessile, oblong or lanceolate; flowers in terminal cymes, pink; petals cuneate, emarginate, crowned; calyx tubular, much enlarged by the ripening pod, its teeth ovate, acute. Jefferson, Monoe, Washington.

12. **Silene antirrhina** L. Sleepy Catchfly. Annual, puberulent or glabrous, glutinous about the nodes, 10 to 20 inches high. Lower leaves spatulate or oblanceolate, narrowed into a petiole; upper leaves linear to subulate; flowers in a loose, cymose panicle, pedicels slender, erect; flowers pink, petals obcordate and minutely crowned; calyx ovoid, glabrous, delicately ribbed, with ovate, acute teeth. General.

13. **Silene antirrhina divaricata** Robinson. More slender, branches spreading, filiform; petals absent. Gallia County.

Saponaria L.

Annual or perennial herbs, with broad leaves and large flowers. Calyx narrowly ovoid or subcylindric, obscurely nerved; petals 5; sepals 5; styles 2; stamens 10; capsule dehiscent by four short apical teeth or valves.

1. **Saponaria officinalis** L. Bouncing Bet. Perennial, glabrous, erect, rather tall, 24 to 32 inches high. Leaves ovate or oval, 2 to 2½ inches long, acute and having a broad, short petiole; flowers pink or white, arranged in terminal corymbs with many small, lanceolate floral leaves; calyx tubular, about an inch long; petals obcordate with a scale at the base of the blade. General.

Vaccaria Medic.

Annual herbs, glabrous, glaucous. Flowers in corymbed cymes; petals pale red and not crowned, longer than the calyx; calyx sharply 5-angled and inflated in fruit; sepals 5; stamens 10; styles 2.

1. **Vaccaria vaccaria** (L.) Britt Cow-herb. Annual, 20 to 24 inches high; calyx 5-angled, enlarged and wing-angled in fruit; leaves ovate-lanceolate. Lake, Ashtabula.

Dianthus. L.

Stiff herbs. Leaves narrow; flowers terminal, solitary or cymose-paniculate, generally purple; calyx tubular, with several bracts at its base; sepals 5; petals 5, long clawed, dentate or crenate; stamens 10; styles 2; capsule cylindric or oblong, stalked, dehiscent by four or five short teeth at the summit.

1. Leaves large, ovate-lanceolate or broadly lanceolate; 3 to 5 times as long as broad; flowers clustered; perennial. *D. barbatus.*
1. Leaves narrowly lanceolate, linear, subulate; 8 to 12 times as long as broad. 2.
2. Calyx densely pubescent; leaves 2 to 2½ inches long; flowers clustered; annual. *D. armeria.*
2. Calyx glabrous or slightly pubescent. 3.
3. Plants much branched; flowers solitary; perennial. *D. deltoides.*
3. Plants simple or with few erect branches; flowers in terminal heads. rarely solitary; annual. *D. prolifera.*

1. **Dianthus prolifera** L. Proliferous Pink. Annual, glabrous, 6 to 12 inches high. Leaves few, linear and acute; flowers small, pink, arranged in terminal, oblong or obovoid heads; calyx concealed by bracts. Cuyahoga County.

2. **Dianthus armeria** L. Deptford Pink. Annual, minutely pubescent, 12 to 20 inches high, with few erect branches. Leaves linear, about ⅛ inch wide, 1½ to 2¼ inches long; flowers arranged in terminal clusters with lanceolate, subulate bracts, usually longer than the calyx; sepals very acute. Licking, Jefferson, Gallia.

3. **Dianthus deltoides** L. Maiden Pink. Perennial, 4¾ to 8 inches high. Leaves short, narrowly lanceolate, glabrous or slightly pubescent; flowers pink or white, solitary, with toothed petals; bracts ovate and half as long as the tube. Lake County.

4. **Dianthus barbatus** L. Sweet William. Tufted, glabrous and erect, 16 to 18 inches high. Leaves lanceolate or ovate-lanceolate; 2½ to 3 inches long, ¾ inch wide; bracts linear-filiform, about the same length as the sharp, pointed sepals; flowers pink or white or variegated, in large terminal clusters. Portage County.

THE GENUS FRAXINUS IN OHIO.

Lillian E. Humphrey.

Recent investigations of the genus Fraxinus show a diversity of opinion in regard to the limits of certain species. A study was made of Ohio forms and comparison made with specimens from other regions in order to determine a suitable disposition of local species.

In Fraxinus lanceolata a very great diversity in the size and shape of the leaflets was apparent. Some of the leaflets from Ohio specimens measured 3 to 7½ inches in length and ½ to 2½ inches in width. Specimens ranging westward to western Kansas have smaller leaves and fruit, the leaflets of those from Kansas measuring 3 to 4½ inches in length and ¾ to 1 5–8 inches in width. The samaras of those from Ohio varied from 1¼ to 2¼ inches in length, while the Kansas type bore fruit measuring 7–8 to 1 5–8 inches in length; both were of about the same width. There is an uninterrupted gradation of sizes and shapes from the larger eastern specimens to the smallest western types. Specimens from Decatur County, Kansas, had the shortest samaras of any examined.

Closely resembling Fraxinus lanceolata in general appearance is Fraxinus pennsylvanica, which differs chiefly in having velvety pubescent twigs and more or less velvety pubescent petioles and under sides of the leaflets. The leaflets are generally broader than those of Fraxinus lanceolata, but of about the same length, the average measurements being 3¼ to 6 inches long and 1 1–8 to 2½ inches wide. In both species both sides of the leaflets are a decided green and the wing of the samara is decurrent 1–3 to ½ the length of the body. Practically the only essential difference between the two forms is the velvety pubescence of the twigs and a usually greater pubescence of the leaves of Fraxinus pennsylvanica.

Parallel with these two forms are Fraxinus americana and Fraxinus biltmoreana, which also seem to be separated mainly by the degree of pubescence. The Fraxinus americana specimens had leaflets measuring 3 to 6½ inches by 1 to 2½ inches. Fraxinus biltmoreana had leaflets of about the same size. The samaras of Fraxinus biltmoreana are 1½ to 1¾ inches long, while those of Fraxinus americana vary from 1 1–8 to 1 7–16 inches. Both have plump, terete bodies and terminal wings. The leaflets of both species are prevailingly whitish underneath. As stated, we have the same conditions as between Fraxinus lanceolata and Fraxinus pennsylvanica. The velvety pubescence of the twigs may be used to segregate the two types, but even this character is not very sharply limited. Often specimens of Fraxinus americana have quite pubescent leaves.

Synopsis.

I. Flowers bisporangiate, imperfectly bisoprangiate, or imperfectly monosporangiate; calyx none or very minute.
  1. Flowers bisporangiate; twigs 4-sided, sometimes sharply four-angled; wing of fruit extending around the body; leaflets green on both sides, not entirely sessile; calyx a minute ring. *F. quadrangulata.*
  2. Flowers imperfectly bisporangiate or imperfectly monosporangiate; twigs terete or nearly so; leaflets sessile; calyx none.
    (1) Leaflets oblong-lanceolate tapering to a long point. *F. nigra.*
    (2) Leaflets oblong to ovate-lanceolate, short pointed. *F. excelsior.*

II. Flowers monosporangiate; calyx evident; leaflets with petiolules.
  1. Fruit with a flattish body passing perceptibly into the wing; leaves and twigs velvety pubescent. *F. profunda.*
  2. Fruit with a terete or nearly terete body.
    a. Wing of the samara extending somewhat down the sides of the body.
      (a) Twigs pubescent. *F. pennsylvanica.*
      (b) Twigs smooth or nearly so. *F. lanceolata.*
    b. Wing of the samara almost entirely terminal.
      (a) Twigs pubescent. *F. biltmoreana.*
      (b) Twigs smooth or nearly so. *F. americana.*

Key to the Species.

1. Leaflets more or less petiolulate. 3.
1. Leaflets sessile. 2.
2. Leaflets 7—11, long, gradually tapering to a point, oblong lanceolate. *F. nigra.*
2. Leaflets short pointed, ovate to obovate. *F. excelsior.*
3. Twigs not quadrangular. 4.
3. Twigs quadrangular; stems sometimes sharply four-angled; leaflets 7—11, green on both sides, upper ones usually sessile, lower ones short petiolulate. *F. quadrangulata.*
4. Twigs pubescent, often velvety. 5.
4. Twigs smooth or nearly so. 7.
5. Leaflets ovate to ovate lanceolate; base usually truncate or rounded, unsymmetrical; upper surface dark yellow green, soft pubescent beneath, calyx large. *F. profunda.*
5. Leaflets ovate, ovate-lanceolate, or lanceolate, usually acute at the base; calyx minute. 6.
6. Leaflets pale beneath, ovate to ovate lanceolate, 7—11; wing of samara terminal or nearly so. *F. biltmoreana.*
6. Leaflets green or greenish beneath, ovate-lanceolate to lanceolate, 5—9; samara with a decurrent wing. *F. pennsylvanica.*
7. Leaflets pale beneath, ovate to ovate-lanceolate, entire or indefinitely serrate, abruptly acute or acuminate, glabrous or somewhat pubescent; wing of samara terminal. *F. americana.*
7. Leaflets green on both sides, glabrous or somewhat pubescent, usually serrate, lanceolate to ovate-lanceolate, acuminate; wing of samara decurrent on the sides of the slender body. *F. lanceolata.*

Fraxinus L. Ash.

Deciduous trees usually with a furrowed bark; light, tough wood; large, light-colored, round pith and large terminal buds. Lateral buds obtuse, somewhat flattened; bundle scars crowded in a curved line; leaves opposite, usually odd-pinnate; flowers inconspicuous, perfectly or imperfectly monosporangiate, some-

times bisporangiate, usually diecious, in bractless pannicles, isobilateral, usually apetalous and dicyclic, but some of the primitive forms with a corolla; cycles usually tetramerous or dimerous; calyx when present usually campanulate, persistent or deciduous, sometimes much reduced; stamens united with the base of the corolla when present; pollination usually anemapholus; ovulary biocular, ovules two in each cavity; fruit a one seeded samara; seed pendulous.

1. **Fraxinus quadrangulata** Mx. Blue Ash. Twigs glabrous or very slightly pubescent when young, 4 sided, sometimes sharply 4-angled leaflets 7–11, ovate to oblanceolate, green on both sides, sharply serrate or serrulate, long acuminate, upper leaflets usually sessile, lower ones short petioled; flowers bisporangiate; corolla wanting, calyx reduced to an obscure ring; samara linear oblong, 1¼ to 2 inches long, 3–8 to ½ inches wide, blunt, body extending half way to the apex. On rich limestone hills and sometimes in fertile valleys. Ottawa, Hancock, Auglaize, Franklin, Licking, Montgomery, Highland, Ross, Brown, Adams.

2. **Fraxinus nigra** Marsh. Black Ash. Twigs and usually the leaves glabrous; leaflets 7–11, sessile, green on both sides, sometimes quite pubescent along the mid-rib, serrate or serrulate, 2½ to 6 inches long, 1 to 1½ inches wide, ovate-lanceolate, with a long, tapering acuminate apex and a narrow or rounded base; flowers imperfectly bisporangiate; samara oblong to linear-oblong, 1 to 1 5–8 inches long, ¼ to 3–8 inches wide; calyx wanting; wing all around the flat body which extends to beyond the middle. In swamps and wet woods. General in northern part of the state, south to Preble, Green, Franklin and Harrison.

3. **Fraxinus pennsylvanica** Marsh. Red Ash. Twigs, petioles, rachis and lower surface of leaflets velvety pubescent; leaflets 5–9, green on both sides, ovate to oblong, margin varying from entire to serrate, apex acute or acuminate, 3¼ to 6 inches long, 1¼ to 2 inches wide; calyx in the staminate flower obscurely toothed, that of the carpellate flower deeply divided; samara 1 to 2 inches long, 1–8 to 3–16 inches wide, wing decurrent, linear to spatulate, about the same length as the body. Low, rich, moist soil. General.

4. **Fraxinus lanceolata** Borck. Green Ash. Twigs and usually the leaves glabrous; leaflets 5–9, green on both sides, lanceolate to oblanceolate, entire to denticulate, 3 to 7½ inches long, ½ to 2½ inches wide, often pubescent on the veins beneath, apex acute to long tapering; samara 1¼ to 2¼ inches long, 1–8 to ¼ inches wide; wing somewhat decurrent, spatulate; body terete. Moist soil. General.

5. **Fraxinus biltmoreana** Beadle. Biltmore Ash. Young twigs very pubescent; leaflets 7–9, pale beneath, more or less pubescent, especially along the veins beneath, ovate to ovate lanceolate, margin entire or sometimes obscurely serrate, rachis

slightly pubescent; samara $1\frac{1}{2}$ to 2 inches long; wing almost entirely terminal, linear, two or three times as long as the short, stout, terete body. Upper part of river banks and woods. Erie, Hardin, Franklin, Montgomery, Morgan, Hamilton, Brown, Lawrence, Meigs.

6. **Fraxinus americana** L. White Ash. Twigs and petioles glabrous; leaflets 5–9, pale beneath, glabrous or somewhat pubescent along the veins, ovate to oblanceolate; margin more or less entire or sparsely toothed; samara 1 to 1 7–16 inches long, 1–8 to 5–16 inches wide; wing entirely terminal; body terete. Rich woods. General.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, April 7, 1913.

The meeting of the Biological Club was called to order by the President and the minutes of the last meeting were read and approved.

The subject of the evening's program was "Regeneration in Animals and Plants."

The first speaker, Prof. Landacre, took up the work of Dr. Childs, of Chicago. Dr. Childs does not accept the term "regeneration," preferring to use "form regulation," which means a return to a state of equilibrium rather than to normal form. More generalized animals do return to normal form, while in the highest animals a process of wound healing is all that takes place.

Dr. Childs further divides form regulation into two main groups—regeneration, or production of new tissue, and redifferentiation, or reorganization of old tissue. He explains these phenomena by a process of "physiological correlation" in growth, which is brought about by "conduction" or the influence of one cell on those near it.

Dr. Dachnowski, the next speaker, discussed the two fundamental phases of regeneration in plants. There are: (1) regeneration which expresses itself in latent buds, or restitution; and (2) that which expresses itself in differentiated tissue. The quality of regenerated tissue varies with age.

He also noted the fact that Sachs worked on the physiological side of regeneration and emphasized the conception of form regulation which Childs uses.

After these papers a discussion was opened in which Profs. Schaffner, Lazenby, Durrant and Barrows took part

Prof. Schaffner emphasized the fact of polarity in plants, which he illustrated and by various illustrations showed that regeneration usually does not indicate lines of phylogeny.

After the discussion was finished, Mr. Walter Marshall was elected to membership. The meeting then adjourned.

Marie F. McLellan, Secretary.

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THE REDUCTION DIVISION IN THE MICROSPOROCYTES OF OENOTHERA BIENNIS.*

Blanche McAvoy.

While making a study of the reduction division in Fuchsia (8) it became necessary to review the literature on the Oenotheras. Finding that Geertz (7), Gates (3, 4, 5 and 6), and Davis (1 and 2), did not entirely agree among themselves and finding also that my study of Fuchsia (8) did not agree in all respects with that of any of the investigations on the evening primrose, I also became interested in the problem presented by the reduction division of Oenothera.

Geertz (7) describes the threads occurring in the early stages of Oenothera lamarckiana as being irregular in thickness and containing small discs of chromatin. He calls the contraction stage synapsis and speaks of loops extending out from the contracted knot. He says the fully formed chromosomes are found immediately after the contraction and that the bivalent chromosomes are produced by a pairing of univalent chromosomes, but he does not find a conjugation of two threads during the contraction. He also observes a longitudinal splitting of the chromosomes just after the transverse split occurs.

Gates has made various studies of the Oenotheras namely O. rubrinervis (4), O. lata xO. gigas (6), O. lata xO. lamarckiana (3), and O. gigas (5). In his paper on O. rubrinervis (4) he insists that the contraction stage is not an artifact but a natural stage leading to synapsis. After the contraction the chromatin material arranges itself in threads which shorten, contract and finally constrict so as to show fourteen univalent chromosomes. These break apart in pairs, each pair fusing together to form a bivalent chromosome. His second paper (6) is a study of the continuity of chromosomes. He claims that there are two methods

*Contribution from the Botanical Laboratory of Ohio State University, No. 76.

of chromosome formation, one involving a side to side pairing, the other an end to end. He finds a continuous spirem and twelve chromosomes but makes no mention as to how the chromosomes are formed. In O. gigas (5) he notes an irregularity in the way homologous chromosomes seem to pair.

Davis first studied the reduction division in O. grandiflora (1). In the early sporocyte he describes chromatin material around the periphery connected by delicate strands. These strands thicken by what seems to be a process of absorption of the chromatin bodies and fill the nucleus with a close reticulum. He calls the synizetic contraction synapsis. At the end of the contraction stage the spirem has assumed the shape of seven bivalent chromosomes some of which, he says are linked together. These rings are later pulled apart on the spindle.

In his second Oenothera paper on O. biennis (2) he calls the dark staining masses found around the periphery of the nucleus prochromosomes. He finds no evidence that they are arranged in pairs, but says whenever there are two together they lie end to end. Later on he finds a spirem out of which is constricted a chain of fourteen chromosomes. He speaks of a longitudinal split which appeared before the heterotypic chromosomes reach the poles.

The buds of Oenothera biennis which were used as material for this study were collected west of Cincinnati during the summer of 1912. They were killed in Schaffner's weaker chromacetic acid and run up through the grades of alcohols to absolute. The imbedding was done from chloroform. Sections were cut 10 microns thick and stained. Both Delafield's and Heidenhain's haemotoxylin were used, the Heidenhain's giving the better results. The iron was used for four hours and the stain over night.

In the very young sporocytes (Fig. 1) there is a reticulum on which can be seen an indefinite number of chromatin masses or granules. A little later (Figs. 2 and 3) this chromatin material collects in seven little masses which represent the protochromosomes. In some of the sporocytes these protochromosomes appear double. Their double nature is more easily studied in the preparation than reproduced on paper for the two parts of a single protochromosome can often be seen best by focusing. The masses are so large that on first sight they might almost be taken for the bivalent chromosomes except for the small size of the young sporocyte and the condition of the tapetum. The tapetum in the younger stages has but one nucleus to each cell while in the later phases each tapetal cell has two nuclei. In passing from the younger to the older stages the tapetum retreats from the sporocyte as the sporocyte increases in size and rounds up. The nucleolus is quite distinct and need never be confused

with the chromatin masses since there is a difference in the way the two stain. The protochromosomes are connected by delicate strands.

Figures 4, 5 and 6 show the protochromosomes in various stages of transformation, while their chromatin is apparently being distributed in the form of granules on the spirem. In Fig. 4 there are still six good sized masses although part of the chromatin has already been distributed. Fig. 5 shows four large masses and two small ones with a spirem forming in the cavity. By the time the sporocyte is as far advanced as the one shown in Fig. 7 the spirem is complete and the protochromosomes are entirely gone. All this time the sporocytes are gradually growing larger.

Somewhat later the chromatin material becomes loosened from the nuclear wall and collapses in a mass in the nuclear cavity, but the synizetic knot is never so close as in some species. Figures 8, 9 and 10 show synizesis in different stages. In figure 10 most of the spirem can be plainly seen. The granules along it are easily made out and the whole spirem is looped and twisted. The nucleolus is not confused with chromatin material on account of the differentiation of the stain. The nuclear cavity is enlarged and frequently the cytoplasm is contracted away from the cell wall. The spirem after the synizesis is granular and looped, and can be traced for some distance. (Fig. 11.)

Figure 12 shows a continuous spirem. In the preparation the spirem could be traced throughout its complete distance without a break. In the drawing the nucleolus seems to cover the spirem and obscure its continuity, but in the preparation, by focusing, the spirem could be seen to be complete throughout its entire length. The spirem is distinctly granular and is thrown into loops three of which can not be mistaken and four more can be made out without much difficulty. Figure 13 shows loops while figures 14 and 16 show seven definite loops. In figure 14 one loop is filled up with stain. In the next figure (Fig. 15) five definite loops show and two masses, one smaller than the other. Figure 16 is probably the best figure to show that the spirem is continuous and is thrown into seven definite loops. Two of them have a double twist. The spirem is granular and lies between the nucleolus and the nuclear wall. In figure 13, 14 and 15 the loops are crossed in the center and beneath the nucleolus and so the continuity of the spirem can not be observed. The looping of the thread shows plainly also in figures 17 and 18, but the continuity of the thread can not be seen plainly on account of the nucleolus. The spirem is granular. In these two sporocytes (Figs. 17 and 18) the nuclear wall seems to be disappearing although in most cases the nuclear wall does not go until the chromosomes are formed.

Gates (4) in his paper on Oenothera rubrinervis states that the spirem constricts into fourteen chromosomes which break apart in pairs and then form the bivalent chromosomes by a folding together and fusion of the parts of each pair. Davis says there are ring-shaped chromosomes, some of which are linked together in O. grandiflora (1). He says these are present as soon as the sporocyte passes out of the synizetic stage. In O. biennis (2) he finds a chain of fourteen chromosomes breaking into seven pairs from which seven chromosomes are formed by fusion. This method of chromosome formation of course is essentially the same as that of loop formation, but I have found the loops defiinitely formed and just as definitely contracting until there are seven chromosomes formed from the seven loops. These results are the same as were found in Fuchsia (8). The loops frequently form quite definite rings as is seen in figure 16.

In figure 19, the chromosomes still show something of their ring and loop character and there are two nucleoli shown. The next figure (Fig. 20) shows a certain amount of loose material in the nucleus which may be derived from the nucleolus although there is no direct evidence for this conclusion. The next two figures (Figs. 21 and 22) show the chromosomes broken apart and the cytoplasm flowing into the nuclear space. The nuclear wall has entirely disappeared. In the cytoplasm are seen great numbers of prominent granules. These remain in the cytoplasm throughout the reduction process. Whether these are starch or not was not definitely determined. Figure 23 shows the beginning of the formation of the spindle with the chromosomes being drawn into the equitorial plane. Figure 24 is the mother star stage at the time when the chromosomes begin to be segregated into the univalents. The next two figures (Figs. 25 and 26) do not show the full quota of chromosomes but show the beginning of the true reduction in those that can be seen. The next two drawings (Figs. 27 and 28) represent metakinesis stages with the chromosomes half way to the poles. Figures 29 and 30 are daughter star stages. The lower pole of figure 30 shows a slight beginning of the nuclear wall. The seven univalent chromosomes are about half the size of those appearing on the mother star. The number can be easily counted at this stage.

Following this stage the nuclear membrane develops rapidly and the daughter nuclei swell to a much larger size. The chromosomes remain as distinct bodies although there is some distribution of the chromatin material (Fig. 31). Even in the resting condition the chromosomes in the two daughter nuclei remain as seven distinct bodies and there is no real reticulum developed (Fig. 32). At this stage all traces of the spindle have disappeared.

Soon after, the second division begins (Fig. 33) and the chromosomes in the mother star are again distinctly visible as small

bodies of the same general shapes as appear in the first division but much smaller. The tetrad (Fig. 34) appears normal, irregularities not being so abundant as in Fuchsia.

SUMMARY.

1. In very early stages of the microsporocytes the chromatin material is scattered throughout the nucleus on a loose reticulum.
2. There are seven protochromosomes formed, some of which show a double nature.
3. These protochromosomes are transformed into a spirem.
4. There is a period of contraction or synizesis during which loops of the spirem project out from the contracted mass. The spirem shows a granular nature.
5. The spirem is continuous and becomes thrown into loops seven of which are shown in many preparations.
6. These seven loops contract until seven separate bivalent chromosomes are formed. About this time the nuclear membrane disappears.
7. The univalent chromosomes remain as seven distinct bodies in the daughter nucleus and are easily distinguishable until the beginning of the second division.
8. The second division follows and results in the formation of normal tetrads. The seven chromosomes are again easily counted in this division although they are much smaller.

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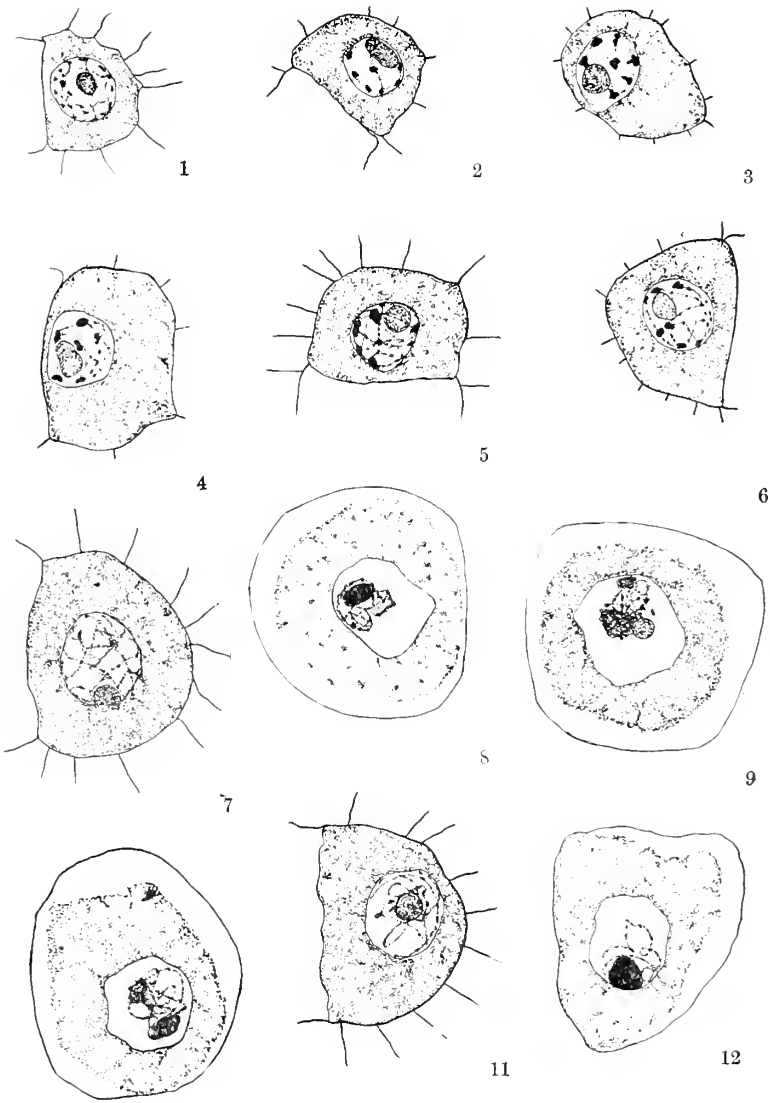
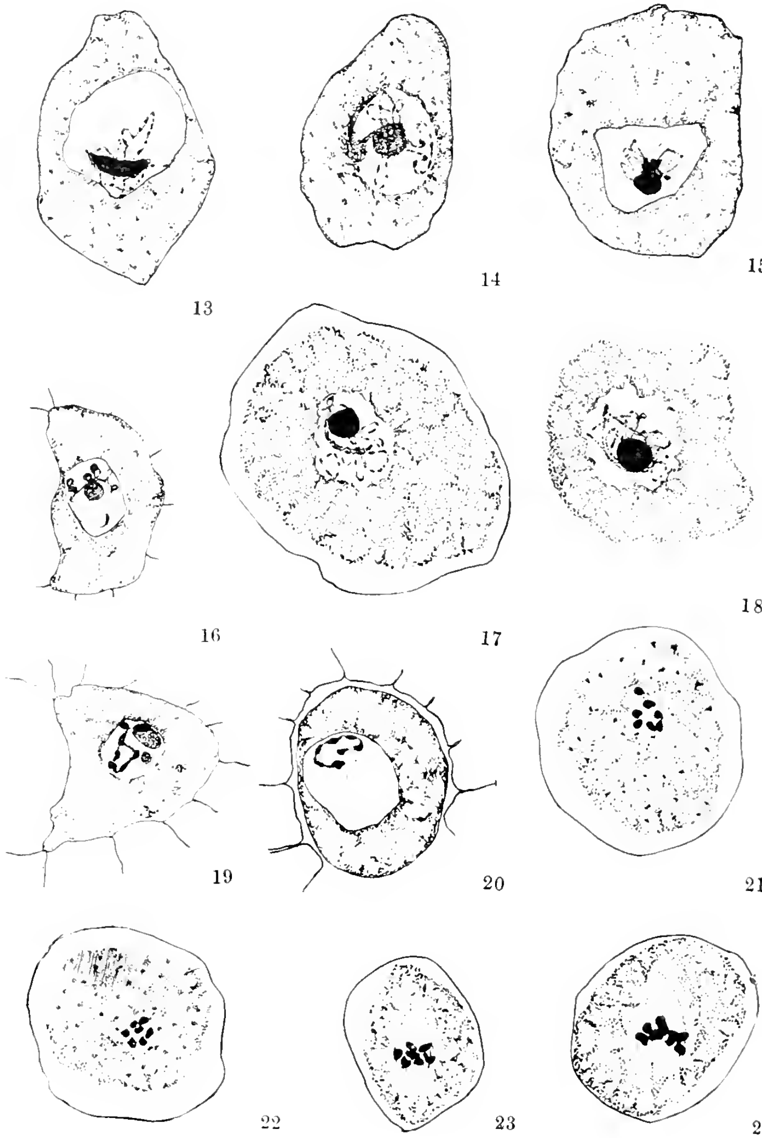
DESCRIPTION OF PLATES IX, X, XI.

Fig. 1. Microsporocyte in early stage showing the chromatin material.
Figs. 2, 3. Microsporocytes showing 7 protochromosomes.
Fig. 4. Microsporocyte showing 6 protochromosomes and some reticulum.
Figs. 5, 6. Microsporocytes in which some of the protochromosomes have been used up in the formation of the spirem.
Fig. 7. Fully formed spirem before synizesis.
Figs. 8, 9, 10. Different stages of synizesis.
Fig. 11. Spirem beginning to show a disposition to loop.
Fig. 12. Microsporocyte which shows a continuous spirem that is thrown into loops, three of which are plainly visible.
Fig. 13. Spirem showing loops.
Figs. 14, 15, 16, 17, 18. Microsporocytes showing the spirem thrown into locps.
Fig. 16. Spirem thrown into seven loops, two of which are double.
Fig. 19. Microsporocyte showing the contracted loops which are forming the bivalent chromosomes.
Fig. 20. Bivalent chromosomes still fastened together.
Figs. 21, 22. Microsporocytes showing the seven bivalent chromosomes completely formed.
Fig. 23. Chromosomes being drawn into the equitorial plane.
Fig. 24. Mother star stage.
Figs. 25, 26. Microsporocytes in which the chromosomes are separating.
Figs. 27, 28. Metakinesis stages.
Fig. 29. Daughter star stages.
Fig. 30. Beginning of the formation of the nuclear membrane around the lower daughter nucleus.
Fig. 31. Daughter skein stage in which the spindle has not disappeared, showing the seven daughter chromosomes in each nucleus.
Fig. 32. Daughter nuclei before the second division showing the chromosomes as seven distinct bodies.
Fig. 33. Mother star of the second division.
Fig. 34. Microspore tetrad.



McAvoy on "Oenothera biennis."



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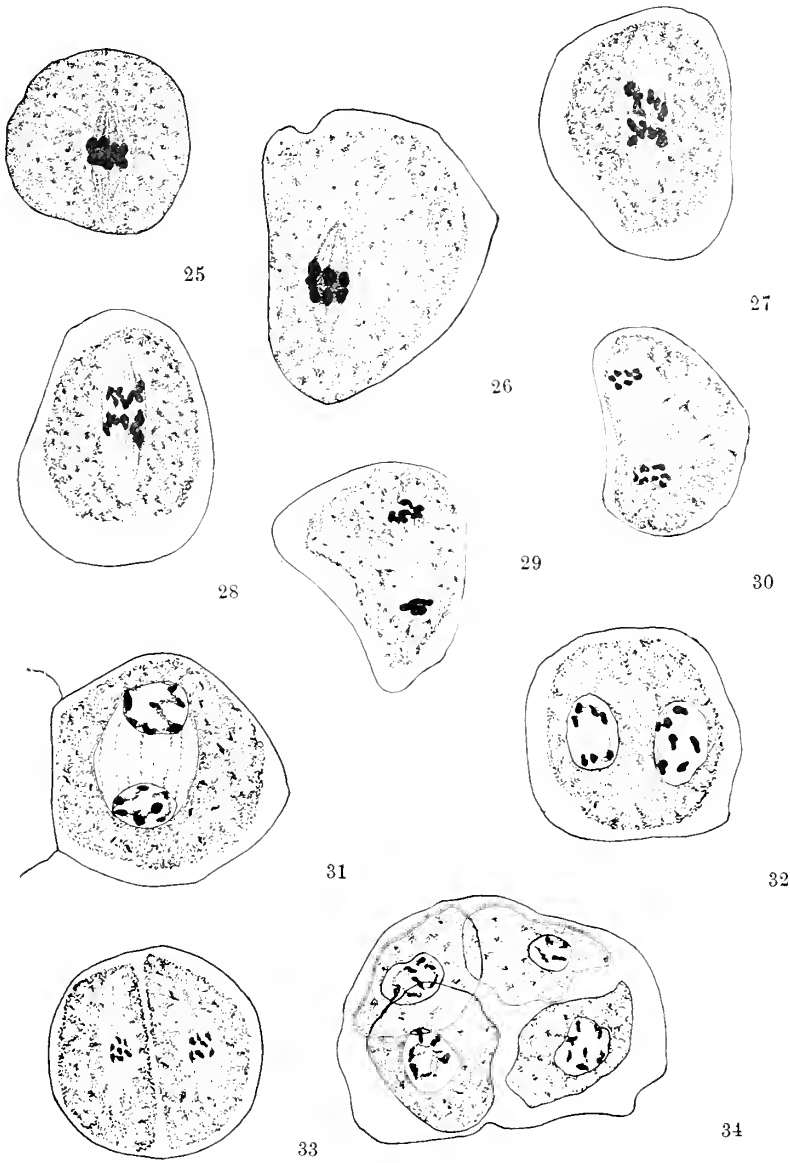

McAvoy on "Oenothera biennis."

THE CLASSIFICATION OF PLANTS, X.*

John H. Schaffner.

Our knowledge of the anatomy, cytology, and life history of many of the groups of Pteridophytes is still far from satisfactory and only a tentative arrangement is at present possible. However, three great lines of development are clearly marked giving three great phyla with which to begin. There may be some dispute as to the true relationship of a few isolated groups but in the great majority of living forms the connection is quite evident. Some of the recent speculations in respect to the Pteridophytes have very little morphological evidence for their support. The writer believes that it is best not to disturb the arrangements of the various groups as accepted in the past until there is more than a mere foundation of assumptions based on doubtful evolutionary hypotheses, many of which are all but disproven at the present time.

There is a notion that external characters are less stable than internal anatomy. But there is really no evidence that this is so. We should first find out whether there is any ecological response and if so whether one set of structures responds more readily than another. Even if it could be shown that there is ecological adaption by direct response to environment or by natural selection this would still be inconclusive, for the internal structure would necessarily have to be co-ordinated with the external. A given type of vascular system may be found in a group and thus indicate relationship, but the same is sometimes true of unimportant external structures like the ligule in Selaginella. The vascular system of the Ptenophyta, for example, shows a remarkable diversity and it is probably because of this very plascity that some of the groups related to this phylum have evolved into the higher forms of seed plants.

The evolution of the Pteridophytes, in general, has been from the homosporous condition to the heterosporous; from the independent gametophytes to minute semidependent gametophytes; from low erect perennials to tree forms with little or no branching to branched forms and from these to geophilous perennials and occasionally to annuals. Several types of leaf venation appear to have developed independently and also several types of vascular system. What the true relationship between the several types is, is at present largely conjecture. There is no definite evidence as to which type of stele is the oldest, nor has there yet been much progress made as to the probable evolution and derivation of the several types. The hiatus between the primordial vascular systems of living Bryophytes and the highly specialized

*Contribution from the Botanical Laboratory of Ohio State University, No. 77.

steles of known Pteridophytes is too great to be bridged unless fossil forms ean be found intermediate between the two. Sinee these forms should be diseovered in the Ordovieian, Silurian, or Cambrian roeks or perhaps in deposits of even earlier age, there is no immediate prospeet of their eoming to light even if any were preserved. The Silurian and Ordovieian should be thoroughly searehed for Pre-Devonian Pteridephytes for Ordovieian fossils might give a elue as to the possible path along whieh the vascular plants evolved. In the meantime it is most reasonable to elassify our living speeies on the basis of their entire morphology both internal and external.

Correction.

Through inadvertance the genus, Mieroeyeas appeared as Mierozamia in the IX paper of this series (Ohio Naturalist 13: 106). Read Mieroeyeas instead of Mierozamia.

In the following synopsis the segregation has been earried as far as the genus exeept in the complex Polypodiaeeae whieh well deserve an independent treatment.

Synopsis of the Ptenophyta.

I. Sporophyte homosporous, having only one kind of nonsexual spores; leaves usually large and mostly compound; gametophytes comparatively large, hermaphrodite or unisexual. Filices. Ferns.

1. Plants eusporangiate, sporangia developed from internal cells. Eusporangiatæ.

(1). Sporangia on a special sporangiophore distinct from the leaf-blade; gametophyte subterranean, without chlorophyll. **OPHIOGLOSSALES.** Ophioglossaceæ.

a. With reticulate venation; sporangia in a single row on both margins of the sporangiophore. **Ophiogossum.**

b. With dichotomous venation, sporangia clustered on the sporangiophore or the sporangiophore more or less branched.

(a). Sporangia opening transversely; on the margin of a more or less branched sporangiophore. **Botrychium**

(b). Sporangia opening longitudinally; in little clusters. **Helminthostachys.**

(2). Sporangia on the underside of foliage leaves; leaves with two stipules; gametophytes with chlorophyll. **MARATTIALES.**

a. Sporangia in sori but free from each other. Angiopteridaceæ.

(a). Sori very long, with 80-160 sporangia; leaves simply pinnate. **Archangiopteris.**

(b). Sori short, elliptical, mostly with 10 sporangia, sometimes less or sometimes as high as 20; leaves two or more times pinnate. **Angiopteris.**

b. Sporangia united forming synangia.

(a). Each loculus or sporangium of the synangium longitudinally dehiscent. Marattiaceæ.

((a)). Synangia elongated, oval, venation not reticulate; leaves large pinnately compound. **Marattia.**

((bb). Synangia round, venation reticulate; leaves digitate. **Kaulfussia.**

(b). Each loculus of the synangium opening by a terminal pore; leaves simple or simply pinnate.

DANÆACEÆ. **Danæa.**

2. Plants leptosporangiate, sporangia developed from superficial cells. LEPTOSPORANGIALÆ. **FILICALES.**

(1). Sporangia without a true annulus, but with a group of thick walled cells which are sometimes arranged in a ring at the apex or side; sporangia nearly sessile; sporophores usually different from the foliage leaves or leaflets.

a. Sporangia with an irrigular group of dorsal thick-walled cells, not arranged in a definite ring, globular; spores with abundant chlorophyll.

OSMUNDACEÆ.

b. Sporangia with an apical ring of cells, ovoid.

SCHIZÆACEÆ.

(2). Sporangia provided with a true, complete or incomplete annulus.

a. Annulus usually complete; that is not interrupted by the stalk of the sporangium.

(a). Sporangia mostly 2 to 8, not on a prolonged or projecting receptacle; dehiscence vertical; indusium none, veins free.

GLEICHENIACEÆ.

(b). Sporangia on a convex, projecting or thread-like receptacle; dehescence vertical, diagonal, or transverse; indusium usually present.

a. Sori round, on the end or the back, or in the axils of the veins.

(a). Sori with 6 to 10 sporangia.

MATONIACEÆ. **Matonia.**

(b). Sori with numerous sporangia.

CYATHEACEÆ.

b. Sori always on the leaf margin at the end of a vein; leaf texture filmy. HYMENOPHYLLACEÆ.

b. Annulus incomplete, interrupted by the stalk of the sporangium; dehiscence transverse; stalk usually long.

a. Usually perennial terrestrial plants.

POLYPODIACEÆ.

b. Annual hydrophytes; sporangia sessile, scattered, covered by the reflexed margin of the leaf. CERATOPTERIDACEÆ. **Ceratopteris.**

II. Sporophyte heterosporous, producing two kinds of nonsexual spores; gametophytes much reduced, unisexual.

1. Plants leptosporangiate, the sporangia in sporocarps, produced on the leaves; leaves without ligules. HYDROPTERIDÆ.

a. Plants rooted, mostly perennial; sporocarp a modified leaflet with a thick, hard wall; terminal bud with a 3 sided apical cell; megasporangia and microsporangia in the same sorus. **MARSILEALES.** MARSILEACEÆ.

b. Plants floating, mostly annuals; sporocarp thin walled, representing a sorus; terminal bud with a two-sided apical cell; megasporangia and microsporangia in separate sporocarps. **SALVINIALES.** SALVINIACEÆ.

2. Plants eusporangiate; sporangia in the bases of the grass-like leaves not in sporocarps; leaves with ligules.

ISOETEÆ. **ISOETALES.** ISOETACEÆ. **Isoetes.** Quillwort.

Synopses of the Families of Filicales Containing More Than One Genus.

No complete presentation is given of the Polypodiaceae, but a few genera are named under each subfamily to indicate the general trend of the phyletic series.

OSMUNDACEÆ.

1. Fertile leaflets not at all or only slightly contracted.
   - a. Epidermis with stomata. **Todea.**
   - b. Epidermis without stomata; leafblade thin. **Leptopteris.**
2. Fertile leaflets much contracted. **Osmunda.**

SCHIZÆACEÆ.

1. Vascular strand central.
   - a. Leaves erect, spores bilateral. **Schizæa.**
   - b. Leaves twining, spores not bilateral. **Lygodium.**
2. Vascular bundles forming a net-like hollow cylinder in the stem.
   - a. Sporangia single or rarely in twos at the end of the vein. **Mohria.**
   - b. Sporangia in two rows along the midrib of the leaf segment. **Ornithopteris.**

GLEICHENIACEÆ.

1. Rhizome erect; leaves simply pinnatified. **Stromatopteris.**
2. Rhizome creeping; leaves mostly dichotomously branched. **Gleichenia.**

CYATHEACEÆ.

I. Sori at the ends of the fertile veins; indusium forming a cup-like sheath together with the more or less modified leaf tip around the sorus.
   1. Annulus of the sporangium with a stoma or mouth of specialized cells.
      (1). Fertile lobe of the leaflet slightly or not at all modified; forming with the indusium a two-valved cup.
         - a. Stem not raised above the ground or only slightly so **Balantium.**
         - b. Aerial stem erect, well developed. **Dicksonia.**

      (2). Fertile lobe of the leaflet highly modified, similar to the Indusium. **Cibotium.**
   2. Annulus of the sporangium with cells all alike. **Thyrsopteris.**

II. Sori on the back or in the fork of the fertile veins; indusium inferior; annulus of the sporangium of nearly similar cells, the mouth only slightly differentiated.
   1. Sorus without indusium. **Alsophila.**
   2. Sorus with an indusium.
      - a. Indusium scale-like. **Hemitelia.**
      - b. Indusium cup-like, with a smooth margin or at first closed and later breaking irregularly. **Cyathea.**

HYMENOPHYLLACEÆ.

1. Receptacle not projecting far if at all beyond the indusium.
   - a. Indusium tubular or cup-shaped; gametophyte filamentous. **Trichomanes.**
   - b. Indusium two-lipped; gametophyte flat or ribbon-like. **Hymenophyllum.**
2. Receptacle projecting far beyond the indusium; sori marginal; indusium urn-shaped. **Loxsoma.**

POLYPODIACEÆ.

I. Sori naked or with marginal indusia.

1. Sori naked or at least without a typical indusium and not covered by the reflexed margin of the leaf-blade.
POLYPODIATÆ. **Acrostichum, Polypodium, Phegopteris, Vittaria.**

2. Sori marginal and usually covered by the reflexed margin of the leaf-blade.
PTERIDATÆ. **Notholæna, Adiantum, Petris, Pteridium, Pellæa, Cryptogramma, Cheilanthes.**

II. Sori with special indusia.

1. Sori linear or oblong, more then twice as long as broad.
ASPLENIATÆ. **Anchistea, Lorinseria, Asplenium, Athyrium, Phyllites, Comptosorus.**

2. Sori roundish, not more than twice as long as broad, usually nearly circular in outline. DRYOPTERIDATÆ. **Dryopteris, Polystichum, Oleandra, Nephrolepis, Davallia, Dennstædtia, Filix, Woodsia, Matteuccia, Onoclea.**

SYNOPSES OF MARSILEACEÆ AND SALVINIACEÆ.

MARSILEACEÆ.

a. Leaves with 4 leaflets; sporocarp bean-shaped, with several to many cavities. **Marsilea.**

b. Leaves grass-like; sporocarp globose, with 2-4 cavities. **Pilularia.**

SALVINIACEÆ.

a. With true water roots; sporocarps (sori) on the floating leaves. **Azolla.**

b. Without roots but with root-like dissected leaves; sporocarps (sori) at the base of the submerged dissected leaves. **Salvinia.**

SYNOPSIS OF THE CALAMOPHYTA.

I. Sporophyte homosporous; leaves united into a sheath with teeth; sporophylls shield-shaped, with sack-like sporangia on the lower or inner side; stem with a ring of vascular bundles and central pith which is usually hollow. EQUISETIEÆ, **EQUISETALES,** EQUISETACEÆ, **Equisetum.** Horsetail, Scouring-rush. Note.—The lowest forms are the large species with evergreen aerial stems of one type; the most specialized species have two types of annual aerial stems.

II. Sporophyte heterosporous; leaves in whorls, free or united into a sheath; all fossil; some of the groups placed here are still imperfectly known and may be homosporous.

1. Stems with a central triarch vascular bundle; leaves not fused into a sheath; sporangia stalked, on the upper side of the sporophyll. Paleozoic herbs or trees.
SPHENOPHYLLEÆ, **SPHENOPHYLLALES.**

a. Leaves small or medium in size, usually more or less wedge-shaped. SPHENOPHYLLACEÆ, **Sphenophyllum.**

b. Leaves large, deeply pinnatifid.
PSEUDOBORNIACEÆ. **Pseudobornia.**

2. Stem with a ring of vascular bundles, increasing in diameter by a cambium zone, and with a central pith, usually hollow; leaves whorled, free or at first united; Paleozoic plants often tree-like CALAMARIEÆ, **CALAMARIALES,** CALAMARIACEÆ, **Calamodendron, Calamites,** and other genera are recognized.

SYNOPSIS OF THE LEPIDOPHYTA.

I. Sporophyte homosporous; leaves without a ligule.
LYCOPODIEÆ, **LYCOPODIALES.**

1. Sporangia unilocular; sporophylls undivided. LYCOPODIACEÆ.
   a. Stems branched, with numerous leaves. **Lycopodium.**
      Note—The lower species are without terminal cones but with zones of sporophylls alternating with sterile foilage leaves, the higher have definite terminal cones.
   b. Stems unbranched with a few basal leaves and a small cone at the tip of a naked peduncle. **Phylloglossum.**
2. Sporangia bilocular or trilocular; sporophylls two-parted.
PSILOTACEÆ.
   a. Leaves numerous, rather large and spreading, with a definite midrib; sporongia with two cavities.
   Tmesipteris.
   b. Leaves small and rather distant without a definite midrib; sporangia with three cavities. **Psilotum.**

II. Sporophyte heterosporous; leaves with a ligule. SELAGINELLEÆ.

1. Without increase in thickness of stem, herbs.
   SELAGINELLALES, SELAGINELLACEÆ, **Selaginella**
2. With increase in thickness of stem, fossil trees. **SIGILLARIALES.**
   a. Leaves spirally arranged, but the bark without parallel vertical flutings or ridges.
   LEPIDODENDRACEÆ, **Lepidodendron, etc.**
   b. Leaves spirally arranged, but the bark with parallel, vertical flutings or ridges, the leaf-scars thus appearing in vertical rows. SIGILLARIACEÆ, **Sigillaria,** etc.
      Note—Several other imperfectly known families belong to this order.

Britton and Brown's Illustrated Flora—The appearanee of the seeond edition of Britton and Brown's Illustrated Flora marks another stage in the progress of Ameriean systematie botany. The revision was made at an opportune time and has been well carried out to meet present eonditions. A eommendable eonservatism is shown quite generally throughout the work in disregarding trivial variations and fluetuations. Mueh improvement is also shown in some new illustrations.

The "Illustrated Flora" will be indispensable to every working botanist in the region eovered. It will be the book to which one will go for the final solution of diffieult systematie problems. It is the desire of the reviewer that this manual shall be taken as the standard referenee for praetieal work on the loeal flora, and the numerous plants submitted from various sourees throughout the state will be referred to its nomenelature. In this way alone will confusion be avoided.

The present work appropriately follows the rules of priority disregarding the legislation of reeent European eongresses, whieh were after all not true representative bodies of the botanists of the world. Had the reeent eongresses been held in New York or on the Paeifie eoast the results, would no doubt, have been different. Striet priority will in the end give more uniform results than

partial authority. But there can be no uniformity of plant names until botanist have discovered the nature and limits of species and genera. To the reviewer, therefore, the retention of the principle of priority in the present manual is one of its commendable features, and will advance rather than retard the progress of American botany.

In the way of criticism it might be pointed out that in some cases there seems to be too great a tendency toward the division of genera and families even when they are naturally rather compact. If this process were to become as prevalent as species splitting has been recently, botanist might well despair. We would soon have local manuals of dictionary size. The study of subgenera and of the myriads of varieties and fluctuations can be accomplished without disturbing the names which are of importance to many who do not devote their entire lives to systematic questions, but who nevertheless, have daily use for the names of many of our economic species.

As in all manuals and treaties of the present time, there are various statements, contrary to the facts, inherited from the superficial past. As an example, the stamens of the Smilaceae are rightly said to be "2-celled," but the same statement is made in regard to the Liliaceae, a number of genera of which, if not all, are known to the writer to have four microsporangia and to be quadrilocular. Neverthless, taken all in all, the "Illustrated Flora" is one of the most comprehensive and accurate botanical works that have appeared in the present generation. J. H. S.

Correction.—In the April number, **Juncus gerardi** Lois was inadvertently omitted. Add this species in the synopsis just before J. dudleyi.

Juncus gerardi Lois. Gerard's Rush.

Plant rather tall and slender, tufted, with creeping rootstock; leaves flat, nonseptate, with membranous auricles; inflorescence paniculate, perianth segments obtuse; stamens 6 barely exceeded by the perianth; capsule longer than the perianth, obovoid and mucronate, trilocular; seed dark brown, acute at the base, conspicuously ribbed. In salt meadows and the vicinity of the Great Lakes. Cuyahoga County.

Add after Smilax pseudo-china the following:

Smilax hispida Muhl. Hispid Greenbrier.

A glabrous, climbing, tendril-bearing vine with branches somewhat angled. The stem commonly bearing numerous, slender prickles; peduncle 1½ inches long; leaves thin, ovate, abruptly acute and cuspidate at the apex, obtuse or sub-cordate at the base; seven-nerved; umbel 10-25-flowered; fruit a bluish-black berry. In thickets. General.

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THE GENUS MYIOLEPLA.

(Family Syrphidae.)

JAS. S. HINE.

The insects falling in this genus are modest colored, medium sized flies usually found about flowers of various kinds in spring or early summer. About a dozen valid species have been described; three or four from the old world, two from South America and seven from North America. M. luteola Gmelin, from Europe, is the type species.

The marginal cell of the wing is open, the anterior cross-vein is distinctly before the middle of the discal cell; antennæ short, but located on a distinct prominence, third segment rather large with a long bare dorsal arista inserted near its base; legs rather stout, all the femora enlarged, and serrate towards the tip but without any distinct tooth, tibiæ all curved. The eyes are holoptic or nearly so in the males and rather widely separated in the female, bare in both sexes. Face hollowed out beneath the antennæ with a prominent facial tubercle in the male followed by an equally prominent oral margin; in the female the concavity beneath the antennæ is a steady curve to the oral margin.

The genus was founded by Newman in 1838 in his Entomological Magazine, Vol. V, p. 373, as Myolepta to receive M. luteola Gmelin. In 1844 Rondani proposed the name Xylotaeja and placed in it Syrphus valgus Panzer. These two species are now considered as belonging to the same genus and since the former, more correctly spelled Myiolepta, has priority it is used by modern students. It is of interest that Walker has referred to this genus as Leptomyia in Insecta Britannica Diptera Vol. I, p. 254. The species do not appear to be so common as many

other species of Syrphidæ. The usual collection does not contain very many specimens. The material for this paper was procured entirely from Dury's collection, from R. C. Osborn's collection and from my collection, the latter now largely with the Ohio State University collection. All the known North American species are represented, but none of them by more than a dozen specimens.

KEY TO THE NORTH AMERICAN SPECIES.

1. Whole body uniform shining black without yellow tomentum or ground color. 2.
   Whole body not shining black often either with dense yellow tomentum or yellow ground color. 3.
2. Legs entirely black. *bella.*
   Middle and hind legs have the first three tarsal segments of each white. *nigra.*
3. Whole body uniform brown with very short yellow tomentum. Each side of the face below with a luteous spot. *strigilata.*
   Body not uniform brown, no luteous spots on the face. 4.
4. Thorax with yellow transverse markings. *transversa.*
   Thorax without transverse markings. 5.
5. Ground color of the abdomen marked with yellow on the sides of first two or three segments. *varipes.*
   Ground color of the abdomen not marked with yellow, body with more or less yellow tomentum. 6.
6. Male. Tomentum of the thoracic dorsum long, entirely hiding the ground color, abdomen with transverse pollinose markings. *aurinota.*
   Male. Tomentum of the thoracic dorsum short and in rows, not concealing the ground color, abdomen without pollinose markings. *auricaudata.*

Myiolepta bella Williston. One of the largest species of its genus, whole body, including the legs, shining black, wings slightly fumose. Length 9 millimeters.

Female: Front and face shining black, not at all pollinose, face longer than in the other species of its genus, hollowed out so that nearly a uniform curve extends from the base of the antennæ to the oral margin. Antenna rather short, first two segments black third segment nearly round, reddish brown with the upper margin darker, arista dark in color and inserted near the base. Thorax with sparse hair which is partially light in color, but mostly black; hair of the legs largely pale, but some black intermixed in places; wings uniform pale fumose all over, veins nearly black, first posterior cell closed a little way from the margin, the petiole much less than half as long as the anterior cross-vein, second vein nearly straight at apex, thus forming a distinct acute angle with the costa and differing in this respect from the other North American species of its genus. Hair of the abdomen pale.

Williston reports three females from Washington and Mount Hood, Oregon; Coquillett studied a male collected by Kincaid at Virgin Bay, Alaska, and R. C. Osborn took a female specimen at Port Renfrew, British Columbia, June 30, 1901. I have used the latter in my study of the species.

Myiolepla nigra Loew. Rather large, black with the exception of the middle and posterior feet which are partially white, wing hyaline at base, unevenly infuscated on distal half; maximum length about 10 millimeters.

Male: Vertical triangle rather small, shining black, frontal triangle and face largely gray pollinose, a patch above the bases of the antennæ, one on middle of face, including the tubercle and extending forward to the oral margin, and the cheeks mostly shining black; antennæ with third segment rather small, brown, arista basal and of the same color as its segment. Thorax with white hair, legs shining black with the exception of the first three tarsal segments on each which are pale, sometimes the front feet are entirely black or the first three segments may be intermediate in color, wings hyaline at base, apical part infuscated, but paler along the posterior margin, first posterior cell closed, the petiole much less than half as long as the anterior cross-vein, second vein abruptly curved at the apex and meeting the costa at nearly a right angle. Abdomen shining black, sparsely clothed with short hair.

Female: Colored like the male, except that the front tarsi are uniform black in all the half dozen specimens studied. Eyes widely separated, front narrowed above; face not tuberculate, gradually concave from bases of antennæ to the oral margin.

Specimens from Medina County, Ohio and from Montreal, Canada. Former writers have reported the species from Pennsylvania, New York and North Carolina.

In Wiener Entomologische Zeitung, Volume I, 1882, pg. 250, Dr. E. Becher has described a species of Myiolepta as M. obscura. There are pretty strong reasons for believing that this is a synonym of M. nigra Lw. I have not been able to procure examples of obscura from Europe, so I have made no comparisons of specimens. Becher's type was procured in Austria.

Myiolepta strigilata Loew. Smaller, rather robust, uniform brown, wings pale yellowish, legs pale from the apexes of the femora. Length 5-7 millimeters.

Male: This sex differs from the same sex in other American species studied in having the eyes narrowly separated. Williston characterized this species by the luteous spot on either side of the face, adjacent to the cheek. In a male before me and in other males I have seen, this spot is very obscure, although present. The whole face and frontal triangle, except the cheeks and tubercle with a narrow extension to the oral margin, is rather densely

white pollinose, thus the spots in question are more or less concealed. Facial concavity beneath the antennæ not very pronounced, facial tubercle small, round and shining black. Antenna brown, third segment somewhat elongate, light brown with the arista of the same color. Thorax brown, with very short, sparse light colored tomentum. Wing nearly uniform pale yellowish, first posterior cell closed, petiole short; second vein abruptly curved at apex meeting the costa at nearly a right angle. All the legs colored alike, each femur dark brown to apex; apex of femur, whole tibia and first three or four tarsal segments pale, last one or two tarsal segments darker usually. Abdomen uniform shining brown with very short sparse, light colored tomentum.

Female: Like the male in color. Facial concavity beneath the antennæ not very pronounced; luteous spots adjacent to the cheeks more conspicuous than in the male.

Specimens from Cincinnati and Columbus, Ohio and from Southern Pines, North Carolina, (Manee). Previously reported from Texas and North Carolina.

Myiolepta transversa n. sp. Rather small, mostly black in ground color, anterior part of thorax with two transverse golden bands interrupted at the middle. Fourth abdominal segment and sides of the third with dense golden tomentum. Wings somewhat fumose. Length 7 millimeters.

Female: Eyes rather widely separated, front narrowed above, front and face with a rather thin layer of golden pollen, cheeks and middle of face shining black, antennæ brown, third segment oblong, longer than the other two segments combined, arista very near the base and of the same color of the segment that bears it. Thorax black, before with two narrow, golden transverse markings interrupted at the middle and a golden transverse spot before the scutellum, pleuræ with sparse white hair, femora dark brown or nearly black, tibiæ lighter, especially at bases, middle and hind tarsi pale brown, front tarsi nearly black, wings slightly fumose, first posterior cell closed, the petiole about as long as the anterior cross-vein, second vein abruptly curved at apex, meeting the costa at nearly a right angle. Abdomen black in ground color, fourth segment and sides of third with golden vestiture.

Type female taken at Puerto Cortez, Honduras, March 23, 1905.

This species is somewhat intermediate between the genera Myiolepta and Syritta. The concavity beneath the bases of the antennæ is very short, and extending from this concavity to the oral margin is a prominent broadly arched carina, a character which does not exactly agree with either genus. The hind femur is larger than those of the outer legs, but otherwise agrees with

Myiolepta; the anterior cross-vein is plainly before the middle of the discal cell while the petiole of the first basal cell is long agreeing with Syritta and with Myiolepta haemorrhoidalis Philippi from Chile.

Myiolepta varipes Loew. Dark colored species with the sides of the first two abdominal segments more or less yellow. Length 6-8 millimeters.

Male: Vertical triangle, a spot above the antennæ, cheeks and facial tubercle and oral margin adjacent shining black; face and front otherwise black concealed by white pollen, antenna pale brown, third segment nearly round, arista basal and of the same color as its segment. Thorax shining black with sparse white tomentum; wing tinged with yellowish, slightly fumose on anterior part near middle and at apex, first posterior cell closed near the margin, the petiole not half as long as the anterior cross-vein, second vein abruptly curved near the apex and meeting the costa at nearly a right angle; legs variable in color, femora often dark, nearly black, but not always, remainder of legs brown, although not always of the same shade. Abdomen yellow on the sides of the first two or three segments, otherwise black. The extent of the yellow of the abdomen is variable but no segment either dorsally or ventrally, is likely to be uniformly yellow.

Female: This sex appears to be uniformly larger than the male, there is more shining space on the face and front and not so much yellow on the abdomen, although the extent of this color is variable.

Specimens from southern, central and northern Ohio. Previous authors have reported it from Colorado, Washington and Oregon.

Myiolepta aurinota Hine. Male, length 9 millimeters. Antennæ reddish, first two segments slightly darker and more shining than the third, third segment slightly narrower than long, arista colored nearly like the segment that bears it, slightly darkened toward the apex. Region surrounding the ocelli, space above the bases of the antennæ, a triangular spot on the face, including the facial callosity, the oral margin adjacent to the facial spot and the cheeks shining black, remainder of front and face gray pollinose, with sparse white hairs near the eyes. Mesonotum including the scutellum entirely golden tomentose, pluræ with white tomentum; wing nearly hyaline, slightly darkened on anterior part more especially toward the apex; general color of the legs black with white hair, all the tibiæ yellow at bases, first two segments of the middle and hind tarsi yellow, first two segments of each front tarsus dusky, but lighter colored than the three remaining segments, all the femora swollen and with short black spines below on apical parts, abdomen black clothed on the dorsum with black and golden vestiture, on sides with white vestiture; the black vestiture of the dorsum is very short and

distributed as follows: the anterior half of the second segment a rectangular patch on the anterior middle of the third segment occupying two-thirds of the length and over half the width of this segment, and a triangular patch on the anterior third of the fourth segment; the golden vestiture is longer and coarser than the black and most dense on the fourth segment; the first segment and all the sutures between segments are thinly gray pollinose, giving the effect of gray bands.

Description taken from the type male which was taken near Phoenix, Arizona, June 18th, 1902, by J. T. Lloyd.

Myiolepta auricaudata Williston. According to Williston's figure and description this is a dark colored species with short golden tomentum on the thorax and on part of the abdomen, especially the last segment. The two sexes are much alike, but the tomentum of the female mesonotum is not so yellow. Length 6-7 millimeters. Not having much material of the species I reproduce Williston's description.

"Male allied to M. strigilata Loew. Body clothed with sparse white or yellow tomentum, this being longer, dense and brassy on the terminal abdominal segments. Vertical triangle long, opaque white in front; contiguity of the eyes short. Face and front clothed with dense white pollen and some golden tomentum on the frontal triangle; a broad shining, bare spot above the base of the antennæ; a transverse band on the face, extending down on tubercle, and the cheeks also, bare and shining black. Tomentum of the mesonotum golden-yellow, arranged in indistinct rows. Second abdominal segment and the anterior part of the third with the tomentum more sparse, apparently bare in certain lights; on the posterior part of the third segment and on the fourth the tomentum is longer, dense, bright brassy-yellow, concealing the ground-color. Legs black; the base of the middle and hind tibiæ, the middle metatarsi, and the hind metatarsi in part, light yellow or white; femora thickened and with spinules below. Wings subhyaline, clouded with brownish distally."

"Female: Front black, with sparse white tomentum and two small, oval, white pollinose spots on each side; face shining black, with an infra-antennal band and a narrow stripe from the eye to the oral margin white-pollinose. Tomentum of the mesonotum more white than in the male."

A female, apparently of this species, before me was taken in the Hauchuca mountains, Arizona. Williston studied two specimens from the state of Guerrero and Morelos, Mexico.

This species is generally darker than strigilata and according to Williston, the antennæ are darker and the facial spots are lacking.

THE CLASSIFICATION OF PLANTS, XI.*

JOHN H. SCHAFFNER.

The various groups of Bryophyta are apparently closely related and it is sometimes difficult to tell what characters are of phyletic importance. There are no fundamental peculiarities or structures which will divide the group into two or three main divisions without considerable overlapping of equally important structures of another type. Thus one is compelled in certain cases to delimit classes and orders on trivial or rather unimportant structures. Nevertheless, the complexity of the group as a whole demands that it should be divided into a number of classes.

The homologies of the various organs are quite evident among themselves and also when compared with the plants immediately above; yet we often find a very illogical terminology and a set of names applied to the various structures which makes comparison with other phyla impossible until special explanations have been made. If we apply a morphological terminology to the mosses and liverworts similar to that used in other groups no difficulty of presentation is experienced. Such an attempt has worked well for the writer in dealing with large numbers of students in general botany.

The synopsis of the Bryophyta given below segregates the main groups and attempts to arrange them in phyletic series.

SYNOPSIS OF THE CLASSES OF BRYOPHYTA.

A. Archegonia not sunken in the plant body; sporophyte without definite intercallary growth between the foot and sporangium.

I. Gametophyte thalloid or with stem and scales, the scales always without a midrib; sporophyte without a stalk or differentiated into foot, stalk and sporangium mostly with elaters, never with a columella, opening irregularly or by a lid, or mostly by four valves. HEPATICAE. Liverworts.

II. Gametophyte with stem and scales, the scales mostly with a midrib; sporophyte usually with a solid stem; sporangium mostly opening by a lid (operculum) or if opening by slits or valves, not with elaters; columella present in the sporangium, complete or occasionally incomplete; archegonium usually developing as a calyptra after fertilization.

*Contributed from the Botanical Laboratory of Ohio State University, No. 78.

1. Sporophyte borne on a pseudopodium developed by the gametophyte; columella not extending through the spore cavity; sporangium without air cavities; without or with a calyptra.
    a. Gray-green bog-mosses with two kinds of cells in the gametophyte; sporangium opening by a lid; archegonium breaking irregularly at the tip. SPHAGNEÆ, Bog-mosses.
    Sphagnales, Sphagnaceæ, Sphagnum.
    b. Dark green rock mosses, not with two kinds of cells; sporangium opening by four or more vertical slits; archegonium developing a calyptra. ANDREÆÆ, Granite Mosses,
    Andreæales, Andreæaceæ, Andreæa.
2. Sporophyte not borne on a pseudopodium, usually with a prominent stalk or seta; columella usually extending thru the spore cavity; sporangium with an air cavity, usually with stomata; archegonium developing a calyptra.
MUSCI, True Mosses.

B. Archegonia having their venters imbedded in the thallus; gametopyhte thalloid, without typical scales; its cells usually with only one or two chloroplasts; sporophyte with intercallary growth between the foot and the sporangium; sporangium with a central columella, opening by two valves, sometimes with stomata.
ANTHOCEROTEÆ, Hornworts, **Antocerotales,**
Anthocerotaceæ, Notothylas, Anthoceros, Dendroceros.

SYNOPSIS OF THE HEPATICÆ.

I. Gametophyte a thalloid, dorsiventral frond composed of several distinct tissue layers; mostly with air passages; sporophyte spherical or with a foot and short stalk; sporangium rarely opening by 4-8 valves.
Marchantiales
1. Sporophyte spherical, without foot or stalk, remaining enclosed in the venter of the archegonium; no sterile cells in the sporangium. Ricciaceæ, Riccia, Ricciocarpus, etc.
2. Sporophyte differentiated into foot, stalk and sporangium, breaking thru the venter of the archegonium at maturity; sporangium with spores and sterile cells which mostly develop as elaters.
Marchantiaceæ, Targionia, Grimaldia, Conocephalus Lunularia, Marchantia, etc.

II. Gametophyte a frond with stem and scales, or if flat and thalloid not composed of several distinct tissue layers, never with air passages; sporophyte consisting of foot, stalk and sporangium, nearly always opening by 4 valves. **Jungermanniales.**

1. Archegonia not terminating the growth of the axis on which they are borne; perigonium not consisting of distinct scales but of a continuous sheath; frond without scales or with imperfectly developed scales. Metzgeriaceæ. Metzgeria, Pallavicinia, Pellia, Fossombronia, etc.
2. Archegonia terminating the growth of the axis; perigonium consisting of scales or occasionally wanting; frond nearly always with 2 or 3 rows of scales. Jungermanniaceæ. Nardia, Lophozia, Kantia, Porella, Frullania, etc.

SYNOPSIS OF THE ODRERS AND MAIN FAMILY GROUPS OF MUSCI.

At present, only a partial segregation of the families of Hypnales and Bryales is attempted.

A. Sporangium without a columella, the sporogenous and vegetative cells commingled; spores very large; archegonium not forming a calyptra but finally rupturing irregularly. **Archidiales,** Archidiaceæ. Archidium.

B. Sporangium with a definite central columella.

I. Archegonia situated on top of short, special lateral branches; peristome when present usually double, developed in the amphithecium from thickened parts of the cell walls; teeth transversely barred, the outer set usually 16, alternating with the inner; frond usually of creeping habit. **Hypnales.**

Eropodiaceæ, Eustichiaceæ, Entodontaceæ, Fabroniaceæ, Hedwegiaceæ, Fontinalaceæ, Climaciaceæ, Cryphæaceæ, Leucodontaceæ, Prionodontaceæ, Crytopodaceæ, Echinodiaceæ, Ptychomniaceæ, Spiridentaceæ, Lepyrodontaceæ, Pleurophascaceæ, Neckeraceæ, Lembophyllaceæ, Pilotrichaceæ, Hookeriaceæ, Ephemeropsaceæ, Hypopterygiaceæ, Helicophyllaceæ, Rhacopilaceæ, Leskeaceæ, Hypnaceæ, Leucomiaceæ, Brachytheciaceæ, Sematophyllaceæ, Rhegmatodontaceæ, Hypnodendraceæ.

II. Archegonia situated at the tip of the main stem or of ordinary branches; frond usually of erect habit.

1. Peristome single or double or sometimes absent, developed in the amphitheeium from thickened parts of the cell walls; teeth always transversely barred. **Bryales.**

   a. Peristome single, seldom wanting.
   Dicranaceæ, Leucobryaceæ, Fissidentaceæ, Calymperaceæ, Pottiaceæ, Grimmiaceæ.

   b. Peristome double at least in its inception, rarely wanting, the endostome thin and membranous.

      (a.) Teeth of the endostome alternating with those of the exostome.
      Orthotrichaceæ, Mitteniaceæ, Drepanophyllaceæ, Schistostegaceæ, Calomniaceæ, Rhizogoniaceæ, Bartramiaceæ, Timmiaceæ, Catoscopiaceæ, Aulacomniaceæ, Meeseaceæ, Mniaceæ, Leptostomaceæ, Bryaceæ.

      (b). Teeth of the endostome, when present, opposite those of the exostome, either free or united with the outer set.
      Funeriaceæ, Disceliaceæ, Oedipodiaceæ, Voitiaceæ, Splachnaceæ.

2. Peristome single or double, developed from two tissue layers of the sporangium; teeth consisting of entire cells, not transversely barred, or if developed from thickened parts of cell walls then the sporangium decidedly dorsiventral and zygomorphic. **Polytrichales.**

   a. Peristome of 4-6 teeth; sporangium actinomorphic. Georgiaceæ. Georgia.

   b. Peristome with numerous teeth; sporangium actinomorphic or zygomorphic.

      (a). Sporangium strongly zygomorphic and dorsiventral. Buxbaumiaceæ.
      Buxbaumia, Webera, Dawsonia.

      (b). Sporangium actinomorphic, usually prismatic. Polytrichaceæ. Catharina, Atrichum, Polytrichum, etc.

PRELIMINARY LIST OF THE SPIDERS OF OHIO.

S. W. Bilsing.

LYCOSIDÆ.

Lycosa carolinensis,
Lycosa scutulata,
Lycosa fatifera.

ATTIDÆ.

Phidippus audax,
Phidippus podagrosus.

CLUBIONIDÆ.

Castianeira descripta

ULOBORIDÆ.

Misumena vatia,
Xysticus gulosus.

PISAURIDÆ.

Dolomedes tenebrosus.

DICTYNIDÆ.

Dictyna frondea.

AGELENIDÆ.

Agelena naevia,
Coras medicinalis,
Tegenaria derhami.

EPEIRIDÆ.

Metepeira labyrinthea,
Lecauge hortorum,
Epeira stellata,
Epeira trivitatta,
Epeira domiciborum,
Epeira foliata,
Epeira trifolium,
Epeira trifolium candicans.
Epeira gigas,
Argiope trifasciata,
Argiope riparia,
Tetragnatha laboriosa.

THERIDIDÆ.

Theridium tepidariorum,
Pholcus phlangoides,
Steatoda borealis.

THE SPROUTING OF THE TWO SEEDS OF A COCKLEBUR.

John H. Schaffner.

In 1901, Masterman reported some observations on the sprouting of cocklebur seeds, showing that both seeds of a bur usually sprout in the same year. This conclusion was at variance with Arthur's experiments; for Arthur had reported that the germination of both seeds of a bur of Xanthium in one season was exceptional. Crocker, in 1906, in his paper on the role of seed coats in delayed germination, reported tests on various cockleburs and stated that high temperature had a decided effect on the sprouting of the seed of the "upper" achene. This fact, no doubt explains most of the discrepancies of reported observations and experiments.

In 1909, the writer studied sprouting cockleburs on the sandy upper beech at Cedar Point, Ohio. A great majority of the burs buried in the sand were sprouting both embyros. In the summer of 1913, further observations were made. Because of the dry weather very few seeds of any kind were sprouting on the upper beech but on the bay side of the Point various low, moist, sandy areas contained abundant cocklebur seedlings. The plants all seemed to belong to the species, Xanthium pennsylvanicum Wallr. Most of the burs had two seedlings. Of those juvenile plants, one was usually larger than the other, as might be expected. Of course, it was not possible to determine whether these burs were one or two years old. But there is no question that in sandy soil with abundant heat and exposure to the sun, the two embryos sprout in the same season. And this is the practical side of the question for the farmer. In a cold climate under certain soil conditions only one embryo may sprout the first season and the other one the second, or even later.

In most cases the one seedling is considerably larger than the other as noted above. This would be expected if one begins to sprout earlier than the other. But there is frequently a difference in size and perfection of the two achenes in the bur. This difference is probably often simply caused by abortive development. The cocklebur has evolved from a small flower cluster, only two flowers remaining. There is little room in the bur and so in the struggle for space and food one achene often has the advantage and develops a better seed than the other. Probably in some species, the one seed is becoming vestigial while in others both achenes still have room to develop normally under ordinary conditions. It will be found on examination that even for normal burs, a certain percent have only one achene with an embryo capable of development.

In conclusion it might be stated that what is frequently taken for the seed-coat in the cocklebur is really the wall of the achene and quite different in structure from a true seed-coat. If past experiments have correlated this pericarp with true seed-coats it may be that further investigations might be of advantage.

Summer in a Bog. Mrs. Katharine D. Sharp, of London, O., has published an interesting little volume with the above title. In the course of the narative many Ohio plants are mentioned with some of their peculiarities, habits, and habitats. There are also paragraphs on the women botanists of Ohio, short biographies on Ohio botanists in general and on some of the great botanists of the world.

Altogether Mrs. Sharp has produced a readable book which will no doubt, lead many a person into the woods and bogs to discover some of the interesting plants enumerated, for themselves. If this result is accomplished and even a few brought into direct contact with nature the book will have performed its mission. There is need for the city dwellers especially, who have mostly been turned to the merry-go-round park and the Sunday picture show, to return to the saner types of recreation.

J. H. S.

Meeting of the Biological Club.

Orton Hall, October 6, 1913.

The first meeting of the year was called to order by the President, Mr. Stover, at 7:45 P. M.

In the absence of the Secretary, Blanche McAvoy was appointed Secretary pro tem. Reports of summer work were given.

Prof. Osborn spent the first part of the summer at Lake Lab. and the latter part collecting leaf hoppers in the State of Maine for economic purposes. He collected 125 new species for the State of Maine and extended the range for 30 species. Prof. Lazenby spoke of the effect of light on certain introduced species of trees, the Norway maple for instance. He also spoke of the scarcity of flies during the summer, due to the precautions used in the different neighborhoods.

Prof. Schaffner told of his observations at Cedar Point. Weeds and introduced species are more plentiful than they were a few years ago. Prof. Schaffner found many ecological variations of the sand bar willow, Salix interior. His state catalogue of vascular plants has been finished. There are 2,065 species of

which about 500 are introduced. Prof. Hine talked of the relation that ants bore to plant lice injury. He spoke of the work that Forbes, of Illinois, has done with corn root aphids.

Prof. Griggs spent his summer in Alaskan waters in a fifty-six foot boat. There were three scientists in the party besides the crew. They traveled by day. From Seattle to Cook's Inlet is entirely forested. Cook's Inlet is a meeting place for all kinds of plants. The expedition collected kelps for the government.

Mr. Sim found several specimens of Lycopodium obscurum in which there were leaves above the cones. Mr. Kostir found the box-elder bug in Sandusky County on August 28, 1913. This is its first appearance in the state. In September they were reported on the campus. Their means of distribution is unknown. Miss Detmers observed the succession of plant associations in the northern peninsula of Michigan, making St. Ignace her headquarters. The region is limestone and has many little lakes and bogs. Sphagnum grows in pools with chara contrary to its usual habit. Mr. Brown reported his work with the trees of Michigan. He was mapping, photographing and working up the ecology of Wayne County. He found two new species for the state. Mr. Stover told of his work with the leaf mold of tomato which he did at Wisconsin.

The Committee recommended Prof. Schaffner for editor and Prof. Hine for business manager of the Naturalist for the present year. A vote of thanks was given these two men for the efficient way in which they have run the paper during the past.

The appointment of a Committee to nominate officers was left to the President. The meeting then adjourned.

Blanche McAvoy,
Secretary pro tem.

AN ADDITION TO THE ODONATA OF OHIO.

Rees Philpott.

The list of dragonflies of Ohio given by Professor Kellicott contained 98 species actually collected, and mentioned one, Anax longipes Hagen, as having been recognized on the wing in June, 1898, by Chas. Dury, of Cincinnati.

Records for this species might lead one to believe that it is partial to coast regions. Hagen and Calvert record it from Massachusetts, New York, New Jersey, Maryland, Georgia, Florida, Mexico, West Indies and Brazil. It is a fact, however, that it has never been reported as common in any region.

This past summer the author had the good fortune to capture a male of Anax longipes on the wing while at the Lake Laboratory, at Cedar Point, Sandusky, Ohio. The specimen was taken July 25th, 1913, about half a mile south of the laboratory, midway between Lake Erie and Sandusky Bay, near a small pool of stagnant water. This capture extends the known distribution of the species westward and suggests the possibility of its presence over a much wider range than actual records would indicate.

Ohio Wesleyan University.

A NOTE ON ANAX LONGIPES HAGEN.

Jas. S. Hine.

Since Mr. Philpott has taken a specimen of Anax longipes at Sandusky, there can be no further discussion as to whether or not it is a member of the Ohio fauna.

This large dragonfly has been of much interest to me ever since Dury related his observation of the species at Cincinnati, in June, 1898. I never doubted the correctness of his observation, but as he did not procure the specimen, there was nothing in our collections of the state to convince others. Dury's statement is published in the Journal of the Cincinnati Society of Natural History, Volume XIX, page 169, and is as follows: "June 2, 1898, one of this species was flying over Glen Lake in Spring Grove. I watched it for two hours, and though it came within a few feet of me, I was unable to catch it. It was a very large specimen, the abdomen bright brick red, thorax and eyes green. June 3rd, I went again to this lake, but did not see it until I moved down to Linden Lake, nearly adjoining, when I again saw it, but failed to catch it. Its flight is steady and in regular

beats up and down the middle of the lake, seldom coming near shore. I made careful search during June, 1899, but did not see any at these lakes."

Two other reports of observations of the species seen on the wing, but not taken, appear in literature: one by Mr. Daecke, at Lucaston, New Jersey, another by Dr. P. P. Calvert, near Poyntelle, Pennsylvania.

The specimen taken by Mr. Philpott is a fine male, having a total length of 81 millimeters to the tip of the appendages; total expanse 112 millimeters; third femur including the trochanter 17 millimeters; third tibia 13 millimeters; abdomen exclusive appendages 53 millimeters; superior appendages 6 millimeters; hind wing 53 millimeters and greatest width of hind wing 14 millimeters. The frons is plain green all over, thorax green, first two segments of the abdomen mostly green, somewhat reddish in parts, abdomen otherwise brick red, membranule dark gray, paler at extreme base, hind wing widest at base gradually narrowed towards apex. Compared with Anax junius from the same locality, longpipes is slenderer, the wings are narrower, the frons is unmarked and the abdomen is colored very differently.

Anax longipes may be considered a tropical species by preference, for most specimens have been taken well south, however, its range is from Brazil to Massachusetts. Its capture is recorded from Brazil, 15 degrees south of the Equator, while the Massachusetts locality is 42 degrees north of the Equator. It does not appear that more than a score of specimens are in the collections of the world.

Mr. Philpott has donated the specimen to the Ohio State University and it will be placed in the Kellicott collection of Ohio Odonata.

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A STARFISH FOUND IN THE WHITEWATER DIVISION OF THE RICHMOND ON BLUE CREEK, ADAMS COUNTY, OHIO.

STEPHEN R. WILLIAMS.

The fossil to be described was not found in place but the shales near by yielded Byssonychia richmondensis and Hebertella sinuata. The Clinton boundary was located on the same branch of the stream at an elevation (estimated) of forty feet above the point of discovery.

The specimen consists of a part of the disc and of two neighboring arms of a starfish. The arms of this starfish were split vertically along the middle of the ambulacral grooves, separating the pairs of ambulacral plates one from the other. Enough of the disc remained to connect the two half arms together and no more. Fortunately the aboral side of the fragment of disc contains the madreporic body.

The preservation of the fossil is ideal. Except for a certain amount of crushing of the aboral skeletal wall together the skeleton shows much as a similar section of a recent starfish does.

Using the dimensions of the two part-arms and disc as a basis for measurement one can reconstruct the whole animal. I estimate that the starfish when living was approximately four inches in diameter from end to end of the rays on opposite sides.

The remains of the disc and longer arm are 40 m. m. long, the disc and shorter arm 35 m. m.

The pairs of ambulacral pieces which formed the ambulacral grooves in the specimen must have been directly opposite each other. This is indicated both by the shaping of the free ends of each ambulacral piece and by some fragmentary remains on the tips of some of the ambulacral pieces on the longest arm. These are very probably ends broken from the plates which formed the other half of the ambulacral groove.

There are 39 ambulacral plates on one half-arm and 29 on the other. The adambulacral plates, sometimes called the inter-ambulacrals, alternate with the ambulacral plates. There are forty of these on the one arm and twenty-seven on the other. The skeleton is complete along the whole of the inter-ray in which the madreporite lies except for the rows of the movable spines which were based on the adambulacral plates.

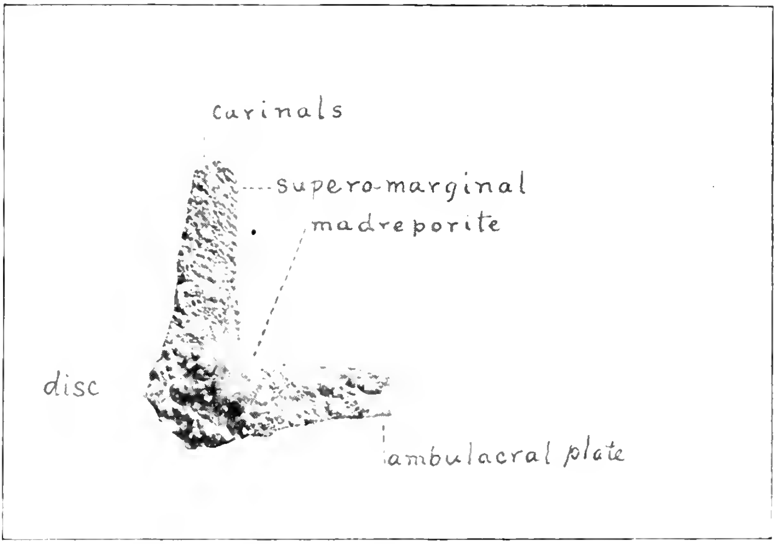

Fig. 1. Promo-palaeaster dyeri Meek (?). Natural size, dorsal view part of disc and arms.

There are a number of starfishes described in the publications of the Ohio Geological Survey. Of these Palaeaster dyeri Meek, (Plate 4 Vol. 1 part 2 of the Palaeontology) resembles most closely the starfish under discussion. The specimen there figured was of a larger animal than this one but as Professor Meek says in his introductory statement, the poor preservation of the parts leaves much to be desired in the description.

The madreporite of P. dyeri is trilobate. Its shortest dimension is in the inter-ray and its longest at right angles to this in the horizontal plane. These dimensions are 6 m. m. vertically and 9 m. m. horizontally.

The madreporic body of my specimen shows a trace of this lobation only. The vertical plane dimension is 7 m. m. while the horizontal diameter is 6 m. m. It has quite a different general shape then from the madreporite of P. dyeri but the size is almost the same relatively, in view of the sizes of the animals. The appearance of the canals on the surface of the two madreporic bodies is very similar, though the pattern of the lines differs with the shape of the bodies.

The aboral side of the rays and disc, as far as can be made out, is rather less regular than the small portion of the aboral side of P. dyeri figured. When one picks out the dorsolateral plates with a lens however many of them are of the same quadrangular type illustrated for P. dyeri. There is also a central depression on eaeh of these plates for the insertion of the spine as in P. dyeri. It is possible that there are some shorter, slighter pieces which lay between the rows of quadrangular or triangular plates.

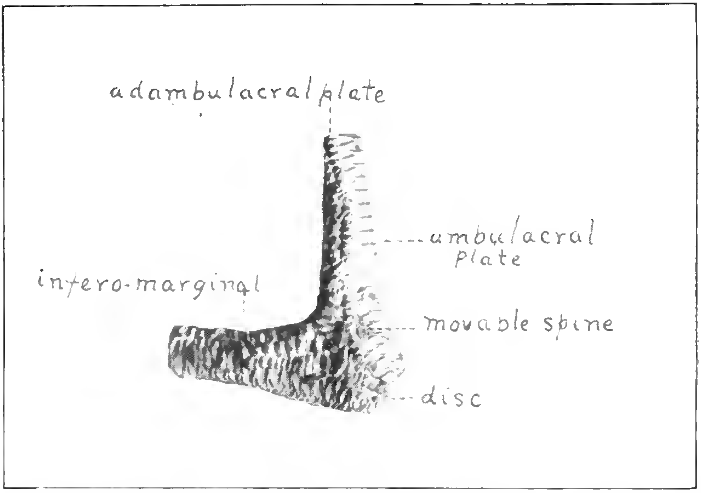

Fig. 2. Promo-palaeaster dyeri Meek (?) Natural size; ventral view part of disc and arms.

The crushing down of the arch of the aboral skeleton and the mixing the broken spines from the surface in with the plates makes it difficult to state precisely how many rows of dorsolateral plates intervened between the supero-marginal plates and the indistinct earinals which occupy the mid-dorsal line. The modern starfish does not have as many dorsolateral plates as another Richmond starfish, Palaeaster magnificus Miller, has. In this respect my specimen seems more like the recent Asterias.

The ambulacral plates seen from below are naturally partly covered by adambulacral plates. There are, however, three ambulacral plates at the end of the shorter arm which have lost their adambulacrals. These are 5 m. m. long and a little more than a millimeter wide. The locations of the pores through which the tube feet passed are easily distinguishable. These pores seem to alternate so that each half of the ambulacral groove would present two rows of tube feet. This alternation is only apparent as there is but one tube foot in the opening between two consecutive ambulaeral plates and one plate between two successive pores. The device is eorrelated in the recent starfish, with a more rapid loco-

motion as more tube feet can be crowded into a given length of arm. We can assume that the alternation served the same purpose in the fossil form.

The adambulacral plates are 3 m. m. long by one m. m. thick. Their third dimension, in the vertical plane is about 2 m. m. The aboral ends of these plates fit in between the outer ends of the ambulacral plates. For this reason they are also called the inter-ambulacral plates.

There is evidence that they bore a double row of movable spines on their oral or ventral aspect, but I am not sure that any of these are preserved. There are a few spindle-shaped spines 3 m. m. long, larger near the outer end and tapering gradually to the point of attachment. Spines like these though larger are the ones which Professor Meek calls the movable spines in P. dyeri. Other fragments of starfishes of undetermined species lead me to think that these might have been the spines broken from the infero-marginal row of plates and that the regular movable spine was more slender.

The infero-marginal plates are elongate near the disc where the arm is thicker and become more nearly cubical, corresponding to the shape figured for P. dyeri, out near the tip of the arm.

Some of these plates show impressions which with some uncertainty I consider to be the remains of pedicellaria around their outer surface. There are also here and there in the spaces between plates isolated structures which might be the larger pedicellaria with the basal plate and two jaws which are found singly in such spaces in recent starfishes.

This specimen shows so many similarities to Palaeaster dyeri, the canals of the madreporite, the shapes of the spines, and of the infero-marginal plates that in spite of differences and pending the publication of an authoritative monograph on the Palaeozoic starfishes by Professor Schuchert of Yale University I refer it to this species.

In a letter Professor Schuchert says that the specimen certainly belongs to his genus Promo-palaeaster and that it may be P. wykoffi, P. dyeri or a new species.

In all events and whatever its name, we have in this fragment of a starfish from the Richmond division of the Ordovician sea, millions of years ago, the plates, the pores, the spines and probably the pedicellaria very similar to those which are found in the starfishes of the present day.

If it is in the direct line of ancestors from which our present day Asterias has decended it adds one more to the list of forms which have been essentially constant for ages and after once becoming fixed have varied only in very slight degrees around the type.

Miami University.

TABANUS LONGUS, FULVULUS AND SAGAX.

JAS. S. HINE.

These three species of North American horseflies have proven more or less troublesome from the standpoint of determination on account of their resemblance to one another and the variation among different specimens of each species as well as their general aspect which corresponds very closely with several other species of their genus.

The following combination of general characters will serve well to group the three species in question and separate them from others similar in appearance: the wings are transparent with no vestige of infuscation on the cross veins or furcation of the third vein; no suggestion of a stump of a vein on the anterior branch of the third vein in any of the specimens I have examined; the costal cell is transparent or very pale yellowish; the general color of all specimens is yellowish or brown, never black; the abdomen has a middorsal stripe with a row of spots on each side; these spots are usually rounded and do not reach the hind margins of their respective segments; in longus the dorsal stripe is narrow and nearly always abbreviated posteriorly and in rubbed specimens may disappear altogether. The characteristic thing about the middorsal stripe in the three species under consideration is its widening on the posterior margin of each segment thus producing an irregular stripe quite different from the regular stripe in costalis, lineola and a long list of other North American species.

With the material at hand the opportunity is given for a study of variation. Each of the three species has been divided into series mainly from the standpoint of coloration and size as not much variation in structure is apparent. Coloration appears to be largely a matter of locality and almost invariably specimens from southern regions are decidedly smaller than those taken well north.

The following key should be of use in separating the species here considered:

1. Third segment of the antenna narrow, without a distinct angle near its base on the dorsal side. **sagax.**

Third segment of the antenna wider, with a distinct angle near its base on the dorsal side. 2.

2. Thorax yellowish, without stripes, middorsal abdominal stripe distinct, front in the female narrow, **fulvulus.**

Thorax brown, often faintly striped, middorsal abdominal stripe narrow and usually more or less abbreviated posteriorly, front in the female distinctly wider. **longus.**

Tabanus sagax Osten Sacken. Middorsal abdominal stripe usually quite wide and extending the full length of the abdomen. Thorax without stripes, uniformly clothed with gray pollen. Front rather wide, sides nearly parallel; frontal eollasity brown, nearly square and with a shining spot above it. Third antennal segment without an angulate prominence at base.

1. Female. This appears to be the form Osten Sacken described as the type of the species. Front rather wide, frontal callosity shining brown, nearly square, almost as wide as the front and with a more or less connected denuded spot above it. Face and front with yellowish gray pollen, the former partially clothed with white down. Palpi stout, pale with black and white hairs intermixed. Antenna yellow with the exception of the annulate portion of the third segment which is clear black, first and second segments with some black hair above, third segment rather long and narrow and without a pronounced basal prominenee. Thorax gray or with a shade of yellowish and without stripes, wings hyaline, costal border pale yellowish; legs largely yellow, front tibia darker apically on account of the presence of black hairs, front tarsus and tips of the other tarsi more or less brown. Abdomen brown in general eolor, dorsal stripe nearly white, wide, expanded at the incisures, lateral rows of spots not very conspieuous but apparent on segments two to six inclusive. Length 13-15 mm. Specimens from Illinois, Massachusetts and New Jersey.

2. Female. A second series is eomposed of similar specimens, the thorax is yellower, the color of the abdomen is lighter brown, the dorsal stripe usually is narrower and the lateral spots are more conspicuous, while the tarsi are not so brown and in some specimens the annulate portion of the third antennal segment is yellow like the basal part or the eoloration may vary thru different shades of brown. Length 11-12 mm. Speeimens from north western Louisiana.

3. Female. Specimens of a third series are smaller still, the width of the thorax and abdomen is decidedly less than in the other two groups. The general color is a slightly darker brown. The middorsal stripe is quite narrow and the lateral abdominal spots are small altho pronounced. The antennae are entirely yellow or the annulate portion of the third segment is some shade of brown. Length 9-11 mm. Several specimens from De Soto Parish, Louisiana.

Tabanus fulvulus Wiedemann. Middorsal abdominal stripe running the entire length of the abdomen, distinct, widened on the posterior border of each segment and with a row of distinet spots on either side. Thorax uniformly pollinose so that no stripes are visible. Front plainly narrower than in either sagax or longus.

1. Female. Front and face yellowish pollinose, the latter with numerous yellow hairs, frontal callosity shining dark brown with an unconneeted elongate shining spot well above it, antenna yellow exeept the annulate portion of the third segment which is black; basal portion of the third segment with a well marked anlge above. Front narrow, sides nearly parallel. Thorax yellowish gray pollinose concealing the ground color, wing hyaline, costal border dilute yellowish as far as the stigma; legs in large part yellowish, all the femora dark nearly to apex, apical part of each front tibia and whole of eaeh front tarsus dark, extreme apex of each of the other tibiae slightly brownish, all but the base of each of the other tari brown. The legs may vary however and in some specimens before me are almost entirely yellowish, other specimens are intermediate in this respect. Abdomen dark brown and yellow or black and yellow, middorsal stripe well marked, widened on the posterior margin of eaeh segment, a row of spots on either side, eaeh spot well defined and more or less surrounded by dark brown or black. Length 13-16 mm. Specimens from District of Columbia, Kentueky, North Carolina and Tennessce. This appears to be the form that Osten Saeken considered as fulvulus in his Prodrome.

2. Female. This form differs from the above mainly in the greater intensity of color, the yellow is golden and the dark is nearly black. On the abdomen the row of spots on either side of the middorsal stripe takes more or less the form of a zigzag stripe on account of each spot reaching the hind border of its respective segment. Length 13-15 mm. Speeimens from St. Simon's Island, Georgia and from Raleigh, North Carolina.

3. Female. Colors paler than in either of the two forms given above, and the size is less. Speeimens are decidedly gray in general appearance, the lateral rows of abdominal spots are small and distinet and surrounded by light brown, while the frontal callosity instead of being nearly blaek is a sort of faded brown. Length about 12 mm. Specimens taken at New Roads Louisiana. At the time specimens were taken it was the only form observed and it appeared to be plentiful. Numerous examples were procured.

4. Female. Size about the same as number 3, altho some specimens are smaller and more slender. The pale legs and entirely yellow antennae are most eharacteristie for this form. The coloration of the body in general is something like specimens of number 1. Length 10-13 mm. More than a dozen specimens from various loealities in Louisiana and Georgia.

Tabanus longus Osten Sacken. Middorsal abdominal stripe very narrow and abbreviated behind in most speeimens, spots in the lateral rows small but distinct. Front in the female wider than in the same sex of fulvulus, widest at vertex and gradually

narrowed towards the antennae. The width and form of the front and the modest brown and gray colors overlaid with a thin coating of gray pollen are characters which easily separate longus from the other two species considered in this paper.

1. Female. This form is considered as corresponding to the typical specimens described by Osten Sacken. Front widest at vertex, gradually narrow toward antennae, frontal callosity pale brown, sometimes darker or even nearly black, higher than wide, with an unconnected spot above, antenna largely yellowish, first two segments clothed with short black hairs, third segment long and narrow with a distinct angle near the base on the dorsal side, annulate portion clear black, cheeks and lower part of the face with silky white hair, palpi white with white and black hairs intermixed. Thorax brown with more or less obscured stripes and gray pollen, wings hyaline, legs largely brown, apex of front tibia, whole front tarsus and apical part of each middle and hind tarsus darkened. Abdomen brown sometimes rather dark, middorsal stripe gray, very narrow, usually abbreviated posteriorly; lateral rows of spots gray, each spot small and usually not reaching either margin of its segment. Length 13-16 mm. Specimens from northern Ohio and Eastern Kansas.

Male. Very much like the female in color. Markings of the abdomen quite distinct. Large and small facets of the eyes plainly differentiated. Length 13-14 mm. Specimens from the same localities as the female.

2. Female. Smaller and of a clearer brown than number 1. Annulate portion of the third segment of the antenna usually brown and not black. In some specimens the middorsal stripe is visible for nearly the entire length of the abdomen and the lateral spots are distinctly larger. Altho structural characters are quite uniform thruout this form and the next appear quite different from typical longus. I have noted that in many species of Tabanus, southern examples are likely to be smaller and of a clearer brown than northern specimens of the same species. Length 11-14 mm. Specimens from North Carolina and Kansas.

3. Female. This form appears decidedly small but measurement of length hardly indicates it because of the slenderness of the specimens. Coloration and appearance are suggestive of form number 2. The atennae are yellowish to the tip. Length 10-13 mm. Specimens from southwestern Georgia.

THE UPPER RICHMOND BEDS OF THE CINCINNATI GROUP.

W. H. Shideler.

Perhaps more geologists, amateur and professional, have been developed upon the Cincinnati arch than in any other region in America. Yet the fact that the beds known as the Saluda have been classed sometimes as occurring beneath the Whitewater beds, and sometimes as above, shows that the Cincinnati stratigraphy is not yet a closed question.

With the hope of determining the exact relationships of the Upper Richmond beds, the field seasons of 1912 and 1913 were spent in studying the upper strata of the northern half of the Cincinnati anticline. The second season's work was made possible by a grant from the Emerson McMillin research fund of the Ohio Academy of Science.

The subdivisions of the Richmond in ascending order have been usually given as Waynesville, or Lower Richmond, Liberty, or Middle Richmond, and Saluda, Whitewater and Elkhorn, constituting the Upper Richmond. We are not concerned here at all with the Waynesville, and but little with the Liberty.

Of these subdivisions, the Saluda beds were the first to be defined*, and were originally termed Madison, from the typical locality at Madison, Ind. But the name being preoccupied, Saluda was substituted.

These Saluda beds at Madison consist of massive, often decidedly arenaceous or argillaceous limestones which have no parallel elsewhere in the northern half of the Cincinnati arch. These heavy strata are of a prevailing grayish color, sometimes bluish or brownish, but weather to various shades of brown. In texture, the rock is smooth-grained and non-crystalline, and except at the top is almost entirely barren of fossils.

The "typical Saluda" of Foerste was given a thickness of 37', being based at the top of 3' of sandy limestones just above the top of a conspicuous 2' reef of the coral Columnaria alveolota. 6' below the base of this reef is the top of another Columnaria reef, 1' thick. Cumings includes both reefs in his Saluda† and identifies the lower one with the reef as the base of the Saluda farther north. But, as will be presently shown, it is the upper reef, not the lower, that extends toward the north and north-east. Hence it seems best here to consider the top reef as the base of the Saluda.

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*Foerste, Indiana Dept. Geol. & Nat. Resources, 21st Ann. Rept., 1896, p. 220.

†Indiana Dept. Geol. & Nat. Resources, 32nd Ann. Rept., 1907, p. 640.

The Liberty or Strophomena planumbona beds were assigned a thickness of about 35′,* and the base was defined as the first recurrence of Hebertella insculpta. The top was not definitely located, but by general agreement seems to have been taken as the base of a 3′-4′ bed of shales and soft, shaly, blocky limestones, containing Trochoceras baeri, and many characteristic Whitewater clams, and with Pachydictya fenestelliformis just above.

The Whitewater or Homotrypa wortheni beds constituted the remainder of the Richmond, until the distinct and even bedded shales and limestones at the top were separated from the very characteristic soft, lumpy, shaly limestones beneath, and called the Elkhorn.

Beginning with the detailed study of the formation at Madison, the lower Columaria reef is here sometimes underlain by as much as 10′ of the general type of Saluda rocks, only rarely massive and with more shale. These strata contain a few poorly preserved Liberty fossils, Homotrypa wortheni, etc. It may be said here that in Indiana the Trochoceras baeri bed is generally undefined, and no sharp distinction can be made between Liberty and Whitewater. These undefined strata have been named Versailles, from Versailles, Ind.†

The lower reef, like the upper, is quite variable in thickness. Averaging 1′ at Madison, it reaches 3½′ in thickness on a north branch of Razor Creek, five miles north, and then thins out and occurs intermittently at several places northward before disappearing.

Between the reefs at Madison are 6′ of shale. This shale is 4½′ thick along the road following the valley of a westward branch of Crooked Creek, three miles north of Madison. Five miles north of Madison the thickness is only 2′ 4″. In the shale are a few poorly preserved Hebertella sinuata, Platystrophia acutilirata, and Dystactospongia madisonensis.

The second reef thins from 2′ at Madison to 1′ toward Hanover, where it has quite a percentage of Calapoecia cribriformis. At the locality three miles north of Madison it averages only 8″ thick, and five miles north is represented only by a hard, tough, irregular limestone 6″-10″ thick with no distinct colonies. Like the lower reef, the second occurs intermittently as far north as the exposures below the road on the West Branch of Laughery Creek, four miles south of Batesville. Huge isolated colonies, sometimes 4′ across, were seen near Versailles.

Above the second reef are 3′-6′ of shales and thin limestones, in some places carrying a prolific mollusc fauna. Just at Madison this fauna is almost absent, but three miles north were collected Dystactospogenia madisonensis, Dowlsonia cycla, Tetradium

*Nickles, American Geol. Vol. 32, 1903, Pp. 207-9.

†Foerste, Science, N. S., Vol. 22, 1905, P. 150.

minus, Calapoecia cribriformis, Hebertella sinuata, Platystrophia acutilirata, Ischyrodonta truncata, Losphospira bowdeni, Liospira sp., Bellerophon sp., Endoceras sp., Primitia glabra, Isochilina subnodosa, Tetradella simplex, etc., etc.

The Tetradium minus is rather scarce at Madison, but is common 1′ above the second Columnaria reef toward Hanover, and again above the mollusc layers 3 miles north. At the locality five miles north it is very abundant through 7′ of blocky, shaly limestones, immediately above the limestones representing the second reef. From here on this Tetradium horizon is very constant, and occurs whereever the rocks have been exposed as far north as Liberty, Ind. and as far toward the east as Oxford, O.

A mile east of Liberty, where the Oxford pike crosses Hannah's Creek, the Tetradium is scattered abundantly through the whole 4′ 9″ of Saluda rocks. Beneath are exposed 3′ of shales and thin limestones with much the same fauna as is carried by the same strata at Laurel.

North of Liberty only three miles, at the last long exposure on Richland Creek, the Saluda strata have almost lost the Tetradium, and are distinctly shaly except at the top, where they end in two heavy limestones, the lower one 1′ 2″ thick and very irregular, the top one 10″ thick and more even. The top stratum is composed largely of fossil "hash," and in this are water-worn Rhyncotrema capax, etc. It occurs at this level to within four miles of Oxford. Immediately above it are the characteristic Whitewater strata and fauna.

The lower shales are partly replaced by evenbedded limestones along Elkhorn Creek, and at the quarries along the Whitewater River south of Richmond are represented by limestones indistinguishable from those below. But the top stratum is still heavy and characteristic.

While perhaps not strictly the equivalent of the second Columnaria reef, this Tetradium reef developed immediately above it and replaced it further north. Outside the Madison region it bases the Saluda type of strata.

Practically whereever this reef is seen it is closely associated with a fauna similar to the one three miles north of Madison. Sometimes this fauna is above the reef or in it, but usually is beneath. Near Versailles the Dystactospongia is especially abundant and just below it are found, besides the molluscs listed above, Ptilodictya magnificia, Monticulipora epidermata, Leptaena rhomboidalis, Agelacrinus cincinnatiensis, and Lichas sp.

At Oxford, Ohio, the first incursion of the Whitewater fauna is preserved in the 3′ of Trochoceras shales, and among the clams are such characteristic forms as Byssonychia grandis, B. richmondensis, Ischyrodonta elongata, I. truncata Opisthoptera casei, Ortonella hainesi, and Whitella obliquata.

Between the top of this bed and the base of the Tetradium reef are about twenty feet of more or less even bedded limestones and shales, so we thus see that there are, here at least, as much as twenty-three feet of Whitewater strata *beneath* the base of the Saluda. Even should we base the Saluda with the lower Columnaria reef at Madison, the result would be but little change, and nowhere could the Saluda be said to be beneath the Whitewater.

Above the Tetradium level at Madison are 37′-40′ of massive, typical Saluda strata, almost wholly barren of fossils except near the top. As one goes north the strata immediately above the basal reef becomes more fossiliferous, the best localities for collecting being near Hamburg, Ind., and Oxford, O., at the latter place being 3′ thick. The fauna is characterized by the scarcity of Brachiopoda and Bryozoa, and includes Leperditia appressa, L. cylindrica, L. caecigena, Ceratopsis chamersi, Eurychilina striatomarginata, Primitia glabra and Tetradella simplex, the first four of these ostracods being recurrent Trenton species. Other fossils are Byssonychia grandis, B. richmondensis, several species each of Cyrtoceras and Orthoceras, Tryblidium indianense, etc., etc. Fragments of a large Euryteroid are found, and remains of plants are occasionally found.

Everything in these strata points to a shallowness of the sea, and a nearness to land, and it is hoped that there will be found in these rocks some definite information as to the nature of the land life of the closing Ordovician.

Above the Saluda type limestones in the Oxford region are about 10′ of thin limestones and shales, sometimes just crowded full of Bryozoa, mostly several species of Homotrypa, including H. wortheni. It is the Bryozoa from these beds that have given the name Coral Banks to the dump from the R. R. cut above Oxford.

West of Cross Plains about one and a half miles, nine miles south of Versailles, a second Tetradium horizon appears, only this "reef" has in places as much Labechia as Tetradium. At Cooper's Falls, four miles south of Versailles, it occurs in the breast of the first little fall below the road, is only 1′ thick, and is about 30′ above the top of the lower reef.

This horizon was not seen at Versailles, but doubtless closer examination would show it. It occurs, however, at all other localities as far north as Laurel and as far eastward as a number of exposures on little tributaries of Indian Creek, three miles west of Oxford, O. In this latter region the Labechia is absent, and the Tetradium forms a definite, hard, massive reef, in places two and one-half feet thick. Most of the colonies are upside down, giving evidence of wave action upon this ancient reef, much as upon the reefs in the present coral seas.

Sometimes 2′-3′ below this second Tetradium reef is another 1′ of Tetradium. Between these Indian Creek exposures and Oxford this reef disappears and is not known to the east.

And between the two reefs at this locality are not only the 10′ of Bryozoa beds, but about 20′ of characteristic soft, lumpy, shaly Whitewater strata with the characteristic Whitewater fauna. The Rhynchotrema dentata beds appear just above the reef. Hence we see from the position of these two reefs that the Saluda is in part the equivalent of the Whitewater.

Returning to the Madison section to pick up another marker and trace it through, we find that the extreme top of the Richmond is again fossiliferous. Just above the Hanging Rock these fossiliferous strata begin with 8″ of thin limestones and dark shale, with Byssonychia richmondensis, Pterinea demissa, Orthoceras hammelli, Labechia ohioensis, and Tetradium minus. Next is a 16″ massive dark limestone, with a richly fossiliferous film of rather poorly preserved fossils on the top. These fossils constitute a distinct and peculiar fauna, part of which appears to have no near relationship in the Cincinnati. The more common species are Labechia montifera, Labechia sp., Streptelasma sp., Ctenodonta sp., Pterinea demissa, Liospira sp., Holopea hubbardi, Lophospira hammelli, Orthoceras hitzi, O. gorbeyi, and Cyrtocerina madisonensis. At the exposures along the road to Hanover, three miles west of Madison, there are added Hebertella sinuata, Platystrophia acutilirata, Leperditia caecigena, Labechia ohioensis and Tetradium minus, there being no distinction here between the two fossil layers as at Madison. This assemblage of fossils constitutes the so-called "Hitz fauna."

Between the Hitz fauna proper at Madison and the Ordovician-Silurian contact, is a 2′ 4″ limestone with all of the ostracods listed from the Saluda of Oxford, except Leperditia appressa, and with Entomis madisonensis added. This ostracod limestone is not distinct at the locality three miles west.

Between Madison and Cooper's Falls the Tetradium and Labechia become consolidated into a rather definite reef, though not of great thickness. At Cooper's Falls this reef is 1½′ thick. It is about 19′ above the second Tetradium reef and 5′ beneath the Silurian contact. These 5′ are massive limestones much like the top limestones at Madison, and carry a reduced Hitz fauna. The Hitz fauna is seen no farther toward the north.

This third reef is seen constantly at about this level, wherever it is exposed, around the northern edge of the Cincinnati outcrops as far east as the vicinity of Waynesville, O. The only place where it was not seen was at Laurel, and a more careful examination of the strata would doubtless show it here.

On Elkhorn Creek the total thickness of the beds between the level of the lower reef and the Silurian contact is about 125′, as

contrasted with 71′ at Laurel and 57′ at Cooper's Falls. The presence on Elkhorn Creek of the upper reef, 8′ 4″ below that Silurian contact, shows that this thickening of strata is due to the more rapid accumulation of sediments toward the north. In the region about Camden, O., which is as far eastward as the Saluda can be traced, the thickness of strata between the level of the lower reef and the upper reef is about 100′, as nearly as the various exposures can be correlated.

It is not the usual thing to have limestones and calcareous shales accumulating more rapidly than the more shallow water sands and shales, but between the limits of the lower and upper reefs on Elkhorn Creek the calcareous sediments accumulated over three times as fast as the argillaceous and arenaceous sediments to the north. The land evidently was so low as to suffer from little erosion, and the sea about it so shallow that the shifting sands and muds were kept stirred up by the waves when not exposed between tides, as shown by the ripple marks and sun cracks at various levels. Thus the organic accumulations here would be reduced to a minimum while to the north the usual favorable conditions would prevail.

Of these 125′ of strata on Elkhorn Creek, about 75′ at the base are typical Whitewater sediments with the typical fauna. The remaining strata are 15′ of barren shale at the base, with predominating shales and more or less even-bedded limestones to the Silurian contact. These strata constitute the Elkhorn beds, and bear a fauna quite distinct from the Whitewater.

The change from the Saluda sediments and fauna begins at Cooper's Falls. Beneath the upper reef there are 7′ of heavy Saluda limestones, and beneath those about 10′ of thin, somewhat lumpy, barren shales and limestones.

At Versailles the second reef was not seen and the sections studied did not run high enough to show the upper reef. But the 10′ of strata at Cooper's Falls are represented at the top of the Versailles section by 9′ of strata which are much softer and more lumpy than at Cooper's Falls, and they bear quite a fauna of a Composite Whitewater—Elkhorn type.

Three miles north of Osgood, on Big Plum Creek and in that vicinity, these strata are thicker, more characteristically Whitewater at the base, then with even bedded shales and limestones up to the upper reef, which is 2′ thick and 5′ beneath the Silurian.

On a north fork of Big Salt Creek, west of Oldenburg, the Richmond ends with 40′ of apparently fossiliferous strata. (The middle of this 10′ is covered.) At the base are about 10′ of strata with Rhynchotrema dentata, Strophomena sulcata, S. vetusta, Platystrophia laticosta, P. acutilirata, Monticulipora epidermata, Batostoma varians, Rhombotrypa quadrata Byssonychia richmondensis, Ischyrodonta truncata, Conularia sp., Cornulites sp.,

Protarea vetusta, Streptelasma rustieum, S. divarieans, ete. ete. At the top are Sehizolopha moorei, Salpingostoma riehmondensis, Platystrophia lynx, the speeies of Platystrophia, Strophomena, and Streptelasma listed above, Rhynehotrema eapax, Protarea vetusta, ete. ete.

On Big Sains Creek near Laurel the 55′ of strata between the seeond reef and the Silurian are largely barren. No good exposures at this level are seen between Laurel and Elkhorn Creek. But between these plaees the fossils become differentiated into the distinet Whitewater and Elkhorn faunas.

Nowhere on the upper half of the Cineinnati areh was more than a loeal uneonformity seen between the Riehmond and the Silurian. Usually it was quite diffieult to tell just where Ordovieian ended and Silurian began.

The upper reef varies in position from immediately beneath the eontaet three miles west of Madison, to an extreme of 14′ beneath it near Waynesville. In this latter region a eonspieuous band of purple shale appears about 5′ above the reef and oeeurs constantly at about this level everywhere on the east side of the arch.

To summarize in eonelusion, all of the Elkhorn and nearly all of the Whitewater are but the deeper water equivalents of the shoal water Saluda to the south.

Seeond: The only Saluda in Ohio is in the northern part of Butler and southern part of Preble Counties.

Third: The third eoral reef and the purple shale together show that the top of the Ordovieian is quite uniform and that any uneonformity is but slight, and close examination of the eontaet bears this out.

Oxford, Ohio.

SOLANACEÆ OF OHIO.

Amy Williams.

In the following study, the genera and speeies have been arranged in what appears to the writer to be their phyletie sequence. Easy keys for identifieation and the distribution in the state, so far as shown by speeimens in the state herbarium, should make a study of the family readily aeeessible to the amateur botanists of Ohio.

SOLANACEÆ. Potato Family.

Herbs, shrubs, vines, or some tropieal speeies trees, with alternate or rarely opposite leaves without stipules, and with hypogenous, bisporangiate, regular or nearly regular eymose flowers. Calyx mostly 5-lobed; eorolla sympetalous, mostly 5-lobed, the lobes induplieate-valvate or plieate in the bud; stamens united with the eorolla, as many as it's lobes and alternate with them,

all equal and perfect in the following genera except Petunia. Gyneeium of 2 united carpels, rarely 3 or 5; ovules and seeds numerous; fruit a berry or capsule.

Key to the Genera.

1. Corolla funnelform, fruit a capsule. 2.
1. Corolla campanulate to rotate, fruit a berry, sometimes nearly dry. 4.
2. Flowers in large terminal racemes or panicles, viscid-pubescent; calyx tubular-campanulate or ovoid. *Nicotiana.*
2. Flowers axillary or in simple, leafy racemes. 3.
3. Calyx tube $1/4$ inch long and with long, leaf-like lobes. *Petunia.*
3. Calyx tube an inch or more long. *Datura.*
4. Stems woody, often with thorns, leaves lanceolate, fruit a nearly dry berry. *Lycium.*
4. Stems herbaceous, or if woody then the leaves lobed or compound, and fruit a fleshy berry. 5.
5. Anthers unconnected, corolla broadly campanulate, fruiting calyx enlarged. 6.
5. Anthers connivent or slightly connate, corolla rotate, fruiting calyx not enlarged. 7.
6. Ovulary 3-5-locular, fruiting calyx deeply 5-parted, corolla pale blue. *Physalodes.*
6. Ovulary bi-locular, calyx 5-lobed, not parted, corolla yellow or whitish, often with a dark centre. *Physalis.*
7. Anthers opening by terminal pores or short slits, leaves entire, lobed or pinnately compound. *Solanum.*
7. Anthers longitudinally dehiscent, leaves usually bi-pinnatifid, or bi-pinnate. *Lycopersicon.*

Petunia Juss.

Viscid-pubescent herbs with entire leaves. Flowers white, violet, or purple, having funnelform corollas with plicate, spreading or slightly irregular limbs; stamens 5, united with the corolla, 4 of them didynamous, perfect, the fifth smaller or obsolete; filaments slender; ovulary bilocular.

1. **Petunia violacea** Lindl. Common Petunia. Very viscid, from 8 to 25 inches high. Leaves ovate or obovate, all but the uppermost petioled, mostly obtuse; corolla commonly violet-purple with a campanulate tube, the limb plicate; sepals linear. Monroe, Franklin. Native of South America.

Nicotiana L.

Viscid-pubescent narcotic herbs or shrubs. Leaves entire or slightly undulate; flowers white, yellow, greenish or purplish; in terminal racemes or panicles; calyx tubular-campanulate or ovoid, 5-cleft; corolla-tube usually longer than the limb, 5-lobed, spreading; stamens 5, united with the corolla; ovulary bilocular, rarely 4-locular; style slender; stigma capitate.

1. **Nicotiana tabacum** L. Common Tobacco. Large, showy herbs about 30 or more inches high. Leaves lance-ovate, decurrent, or the upper ones lanceolate; flowers rose-purple, in panicles with funnelform corolla, with somewhat inflated throat and short lobes. Huron, Adams. Escaped from cultivation.

Datura L.

Large narcotic herbs, or rarely shrubs or trees. Leaves petioled, alternate; flowers large, solitary, erect, short-peduncled and white, purple or violet; calyx elongated-tubular or prismatic, 5-cleft; corolla funnelform, 5-lobed, the lobes plicate, broad, acuminate; stamens included or little exserted, with long, filiform filaments, united with the corolla tube to about the middle.

1. Leaves entire, calyx tubular. *D. metel.*
1. Leaves lobed and angled, calyx prismatic, flowers white to purple. *D. stramonium.*

1. **Datura metel** L. Entire-leaf Jimson-weed. Annual; finely glandular-pubescent, 3 to 9 feet high. Leaves broadly ovate, acute, inequilateral, rounded or subcordate at the base; flowers white, corolla about twice the length of the calyx; capsule nearly globose, obtuse, prickly and pubescent. Lake county. From tropical America.

2. **Datura stramonium** L. Common Jimson-weed. Annual, glabrous or the young parts minutely pubescent. Stem stout; leaves ovate, acute or acuminate, often with a tinge of purple, irregularly sinuate-lobed, the lobes acute; flowers white or violet; calyx prismatic; capsule ovoid, prickly. General. Naturalized from the tropics.

Lycium L.

Shrubs or woody vines, with small leaves and with smaller ones in fasicles in the axils. Flowers white, greenish or purple, solitary or in clusters; calyx campanulate, 3 to 5-lobed; corolla tube short or slender, the limb 5-lobed (rarely 4-lobed), the lobes obtuse; stamens 5, (rarely 4) filaments filiform.

1. **Lycium halmifolium** Mill. Matrimony-vine. Glabrous, with thorns or unarmed. Leaves lanceolate, oblong, or spatulate, with short petioles; stem slender, climbing or trailing; thorns when present slender; calyx lobes ovate; corolla purplish, changing to greenish; stamens slightly exserted; berry oval, orange-red. Rather general. From Europe.

Physalodes Boehm.

Annual, erect, glabrous herbs. Leaves alternate, petioled, sinuate-dentate or lobed; flowers large, solitary, light-blue, nodding; calyx-segments ovate, connivent, cordate or sagitate at the base, netted-veined; corolla broadly campanulate, slightly 5-lobed; stamens 5, included, united with the base of the corolla.

1. **Physalodes physalodes** (L.) Britt. Apple-of-Peru. Plant 18 to 45 inches high with angled stem. Leaves ovate or oblong, acuminate but blunt, narrowing into a long petiole; limb of corolla almost entire; segments of the fruiting-calyx terminating in cusps, loosely surrounding the berry. Hamilton, Clinton, Clark, Franklin, Licking, Gallia, Montgomery, Champaign. From Peru.

Physalis L.

Herbs with entire or sinuately toothed leaves. Calyx campanulate, 5-toothed, when in fruit much enlarged and 5-angled or 10-ribbed and reticulate, wholly enclosing the pulpy berry; corolla often with a brownish or purplish centre, open-campanulate, or rarely campanulate-rotate, plicate; stamens united with the base of the corolla.

1. Stems glabrous or only slightly pubescent, peduncles usually longer than the flowers, leaves usually acute or acuminate at the base. 4.
1. Stems very pubescent or wooly; peduncles usually shorter than the flowers; leaves usually shorter than the flowers; leaves usually cordate or truncate at the base. 2.
2. Leaves with long hairs, plants perennial; fruiting-calyx pyramidal, 5-angled and with long points. *P. heterophylla*
2. Leaves with short pubescence, plants annual; fruiting-calyx rather small, points very short. 3.
3. Plant green, leaves ovate, usually only slightly cordate at the base, nearly entire or dentate. *P. pruinosa.*
3. Plant somewhat hoary; leaves cordate at the base, strongly oblique, coarsely sinuate. *P. pubescens.*
4. Leaves ovate-lanceolate; fruiting-calyx green. 5.
4. Leaves broadly ovate, acute; fruiting-calyx red. *P. alkekengi.*
5. Stem usually not 2-forked; leaves not decidedly dentate toward the tip; fruiting-calyx ovoid. 6.
5. Stem noticeably 2-forked; main-stem erect; fruiting-calyx pyramidal, 5-angled, deeply sunken at the base; leaves usually dentate at the outer end. *P. virginiana.*
6. Peduncles shorter than the flower; annual. *P. ixocarpa.*
6. Peduncles longer than the flower; perennial by rootstocks or roots. *P. lanceolata.*

1. **Physalis lanceolata** Mx. Prairie Ground-cherry. Plant with slender, creeping root-stock. Young stems erect, later spreading or diffuse, slightly angled, somewhat hirsute with flat hairs; leaves mostly entire, sometimes slightly lobed, sparingly covered with short hairs; calyx lobes triangular-lanceolate, when in fruit round-ovoid, not sunken at the base, indistinctly 10-angled; corolla dullish yellow with a brownish centre. General.

2. **Physalis ixocarpa** Brot. Mexican Ground-cherry. When young erect, later widely spreading; stem angled, glabrous or the younger parts slightly hairy; leaves cordate to ovate with a cuneate base, sinuately dentate or entire; calyx slightly hairy; corolla bright yellow with purple throat; fruiting-calyx round ovoid, obscurely 10-angled, often purple veined; berry purple, filling the husk. Franklin county. Native of Mexico.

3. **Physalis virginiana** Mill. Virginia Ground-cherry. Perennial; about 14 inches high; stems slightly angled, strigose-hairy with flat hairs, or glabrous; dichotomously branched; leaves ovate-lanceolate, usually sinuately dentate; peduncles in fruit curved but scarcely reflexed; calyx lobes triangular or broadly lanceolate, nearly equalling the tube; flowers sulphur-yellow with purplish spots. Cuyahoga county.

4. **Physalis alkekengi** L. Chinese Lantern (Ground-cherry) Perennial. Leaves thin, broadly ovate, entire or angled; fruiting calyx much enlarged, veined, scarlet or crimson. Persistent after cultivation. Franklin, Lake.

5. **Physalis heterophylla** Nees. Clammy Ground-cherry. Perennial by a creeping rootstock, viscid and glandular, 12 to 18 inches high, with long, spreading, jointed, flat hairs; leaves acute, very rarely with an acumination, thick, sinuately toothed or sometimes subentire; calyx long-villous with triangular lobes usually not as long as the tube; corolla greenish-yellow with a brownish or purplish centre. General and abundant.

6. **Physalis pubescens** L. Low Hairy Ground-cherry. Plant pubescent, with spreading stems slightly swollen at the nodes. Leaves ovate, acute, or acuminate, slightly cordate, upward repand-denticulate or entire, pubescent, sometimes becoming nearly glabrous except along the veins; corolla yellow with a dark centre; calyx lobes narrow, in fruit membranous, pyramidal, ovoid-acuminate, retuse at the base. Shelby, Morgan.

7. **Physalis pruinosa** L. Tall Hairy Ground-cherry. Stout, generally erect, quite hairy. Stem finely villous or somewhat viscid; leaves finely pubescent, ovate, cordate, and deeply sinuately toothed; calyx villous or viscid, its lobes as long as the tube, narrow but not subulate-tipped; fruiting calyx reticulate, ovoid, cordate; berry yellow or green. Franklin county.

Solanum L.

Herbs or shrubs, often stellate-pubescent, sometimes climbing. Flowers cymose umbelliform, paniculate, or racemose; calyx campanulate or rotate, usually 5-cleft; corolla rotate, the limb plaited, 5-angled or 5-lobed, the tube very short; stamens united with the corolla, filaments short.

1. Leaves compound or divided. 2.
1. Leaves entire, toothed, or merely lobed. 4.
2. Plants not prickly. 3.
2. Plant and enlarged fruiting-calyx very prickly; one stamen enlarged and beaked. *S. rostratum.*
3. Herbs with tubers; stems prominently wing-angled. *S. tuberosum.*
3. Climbing vines, more or less woody; stems not winged, or only slightly angled. *S. dulcamara.*
4. Plants prickly or if only slightly so, then stellate-pubescent, or silvery-canescent all over. 5.
4. Plants glabrous or somewhat pubescent, not prickly or silvery-canescent; ripe berries black. *S. nigrum.*
5. Leaves repand-dentate or entire; densely silvery-canescent. *S. eleagnifolium.*
5. Leaves lobed and angled; hirsute. *S. carolinense.*

1. **Solanum elaeagnifolium** Cav. Silverleaf Nightshade. Perennial, silvery-canescent all over. Stem sometimes with sharp prickles; leaves lanceolate, oblong or linear, petioled, mostly obtuse, repand-dentate or entire; flowers cymose; peduncles short;

calyx-lobes lanceolate or linear-lanceolate, acute. Lucas county. (a waif.)

2. **Solanum carolinense** L. Horse-nettle. Stellate-pubescent with 4 to 8 rayed hairs, erect, branched, prickly. Leaves oblong or ovate, repand, lobed or pinnatifid; flowers cymose-racemose with pedicels recurved in fruit; petals ovate-lanceolate, acute; calyx-lobes lanceolate, acuminate, about half the length of the corolla, persistent at the base of the berry; berries orange-yellow, glabrous. General.

3. **Solanum tuberosum** L. Potato. Plant erect, finely pubescent. Leaves pinnate, made up of several ovate leaflets and some minute ones inter-mixed; flowers blue or white, arranged in cymes; sepals about half the length of the petals; berries round, green. Franklin, Ottawa, Erie, Tuskarawas, Hocking, Monroe.

4. **Solanum dulcamara** L. Bitter-sweet. Perennial; stem climbing, somewhat woody below. Leaves ovate or hastate; petioled, acute or acuminate, entire, 3-lobed, or 3-divided with the terminal segment the largest; flowers blue, purple or white in compound lateral cymes; corolla 5-lobed, petals triangular-lanceolate, sepals short, oblong, obtuse, persistent at the base of the berry; berry oval or globose, red. General in northern Ohio as far south as Clark, Licking and Jefferson counties; also in Meigs county.

5. **Solanum nigrum** L. Black Nightshade. Annual, glabrous or slightly pubescent, about 15 inches high. Leaves ovate, petioled, more or less inequilateral, acute, acuminate at the apex; flowers broad, 3 to 10 on an umbel; calyx-lobes much shorter than the corolla, persistent at the base of the berry; berries glabrous, globose. General and abundant.

6. **Solanum rostratum** Dun. Buffalo-bur. Densely pubescent with 5 to 8 rayed hairs and covered with yellow subulate prickles. Leaves ovate or oval in outline, irregularly pinnately 5 to 7 lobed or 1 to 2 pinnatifid; flowers in lateral racemes; pedicels erect both in flower and fruit; calyx densely prickly, entirely covering the berry. Franklin, Marion, Ottawa, Cuyahoga, Summit, Lake. From the west.

Lycopersicon Mill.

Annual, or rarely perennial, coarse herbs with 1 to 2 pinnately divided leaves and flowers in lateral irregular racemose cymes opposite the leaves. Corolla rotate, the tube short, the limb 5-cleft rarely 6-cleft, plicate; calyx 5-parted rarely 6-parted.

1. **Lycopersicon lycopersicon** (L). Karst. Tomato. Viscid-pubescent, much branched, one to several feet high. Leaves petioled, ovate or ovate-lanceolate, mostly acute, dentate, lobed or again divided with several or numerous small leaflets, sepals about equalling the petals. Rather general as an escape.

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TRANSPIRATION IN RELATION TO GROWTH AND TO THE SUCCESSIONAL AND GEOGRAPHIC DISTRIBUTION OF PLANTS.*

ALFRED DACHNOWSKI.

In former publications (Botanical Gazette 49; 325-339, 1910; Ibid 54; 503-514; Bulletin 16, Geological Survey of Ohio, 1912) the writer invited a closer consideration of a number of points of interest to students of modern phases of Botany. Among other matters, attention was called to the fact that while the presence of structural modifications is generally regarded as a condition in favor of certain plants which are limited to habitats favorable to them, the more noteworthy characteristic is very likely functional variability, when plants extend the areal range beyond their typical habitats. It is a well known fact that plant migrations are not completed as yet, and that vegetational limits are determined more frequently by developmental than by climatic or edaphic conditions. European ecologists especially have furnished notable instances of this character, and the more important results of the several International Phytogeographic excursions into various parts of the world tend to give prominence to the problem of functional plasticity in plants of the same species, but of ecologically and geographically separate regions. Relative power of endurance and acclimatization are questions of special significance also in the existing peculiarities of scattered geographical distribution as well as in physiological ecology.

*Contribution from the Botanical Laboratory of Ohio State University, No. 80.

Examples of a more local nature are cited in Bulletin 16, in the chapters dealing with the historical factors of bog vegetation and the succession of vegetation upon peat soils. It is there shown that areal movements of vegetation during remote geological periods of time as well as to-day, are determined partly by the external conditions to which a plant or the social aggregate is exposed and partly by the functional limits of the organic units, these two sets of factors themselves progressively changing as vegetation types evolve. A further consideration of importance is the theory entertained that the change of conditions, in the remote past, following the accumulation of organic soil (peat-like in nature) and the invasion of it by organisms originally aquatic, had played a prominent part in the establishment of a land flora and the further differentiation of it into those alternating phases of the life cycle which are so characteristic of archegoniate plants.

In the work of an experimental nature, the writer brought out the fact that the point of most importance which should be noted in this connection is the difference in the water requirement of plants. The experiments cited showed clearly that transpiration is not a measure of growth even under the same atmospheric conditions, and can not be looked upon as the most striking criterion for such colonists among plants as are steadily coming into a new habitat and succeed to establish themselves as dominants or in competition with the plants constituting the association.

The term "water requirement" is a word which enjoys the advantage of brevity as well as euphony, but it is also another instance of the rather numerous cases in the literature of applied botany of the misleading use of terms. It is assumed by many writers that a definite and quantitative relation exists between transpiration and growth, and that hence the ratio of the weight of water absorbed and transpired by a plant during its growth to the green or dry substance produced is an adequate and simple measure of growth. The generalization from the data presented by them is too broad; it is seriously inadequate to account for numerous exceptions in the investigations bearing on this subject, and is certain to lead to error. It is needless to say that any measure of "the agricultural duty of water," of the water economy of crops or of native vegetation types; any action looking toward the better utilization and management of water resources for irrigation; any estimation of the capacity of a land area for crop production or for the probable future population it may support; any study of the geographical movement of vegetation, if made on the basis of this standard of water use in relation to plant growth, must be influenced by the congruity of the relationship and the magnitude of the value involved.

It is neeessary either to abandon the term, because investigators are no longer eertain of denoting eonsistent results obtained by means of the value, or to ehange the meaning of the term so that it may earry with it the implieation which appears in the experimental results of various workers.

In most of the researeh that has been made on the water requirement of plants the investigators have not fully eonsidered the relation of transpiration to growth. Transpiration is undoubtedly of value as an indieator of different soil and climate conditions and in exhibiting differences whieh exist between different species and varieties of plants. The general literature bearing upon transpiration has been so well brought together and summarized that a review of it need not be given here. Among the different faetors which are direetly related to the problem and whieh affeet physically the transpiration value of plants may be mentioned the water content of the soil, the saturation defieieney of the air, and the eharaeter of the plant, length of active period, relative size, root and leaf area, morphological structure, etc. Of these faetors the soil water content is considered to be the most important and more eomplex variable. Its value is a funetion of the structure, type and amount of soil, tillage, the per eent of humus and elay eontent, and the quantity of mineral salts (here eonsidered merely as affecting the vapor pressure of water). These conditions modify also the rate of water movement. The value of the transpirational water loss may be determined and expressed as a ratio in terms of any one condition affeeting it direetly, but whieh of these is the better criterion may be left in abeyanee for the present. The transpiration ratio may fittingly be ealled the ecologieal water requirement. As a eriterion for eomparing the available water of agrieultural soils; as a measure of the quantity, the permanenee or the fluetation of the water relation of plants in their habitat, transpiration under these eonditions is very important, and an adequate and simple index of habitat eonditions. It is greatly inereased with the higher soil water eontent and deereases within limits as the soil moisture is lowered; where the range in soil water is small the effeet is not marked. The loss of water from plants is inappreeiable in saturated air, is greater in dry than in moist atmospherie eonditions, and less for plants nearer the ground stratum. Under these eonditions (assuming in all eases that seeondary injurious eonditions are eliminated) it indieates the eontinuity of the water relation between the soil, the plant and the air—the water is absorbed without greatly altering or expending the energy of eell eonstituents. The transpiration ratio indicates the magnitude of the water faetor within the zone of shoot and root aetivity which controls the individual plant or the assoeiation; it further indieates the limiting

values that produce the effect of wilting and drought, and determine the differentiation of the vegetation by the local occurrence of soil types. It enables to that extent a correlation between available water and the invasion, succession or reversion, under natural conditions, of one vegetation type to another. The formula unquestionably provides values which are sufficiently distinctive to characterize diverse plants and diverse habitats, and which may serve also as a criterion for the range of deviation, the maximum and minimum transpiration value for the limits of the existence of plants as individuals or as groups, and for the geographical distribution of plants where this is determined physically by soil, climate or competition. However, correlations of transpiration with growth or green and dry weight of plants are by no means as clear as they should be; they must be more thoroughly tested.

Critical researches are required in at least three experimental fields of investigation to determine (1) how far the observed results in growth, structural character, size and weight of plants depend on differences in the relation subsisting between absorption from the soil and transpiration into the air, (2) how far they are due to the differences in the amount of water present and retained within the plant, i. e., to differences in the physiological water balance in plants, and (3) how far they are determined by the biochemical relations of the root-system with the soil-water constituents and with metabolism. Here the growth increment is the important criterion, and the ratio which is used as the index of the physiological water requirement (to distinguish it from the other term used on the basis of the environmental water relation) may well be called the coefficient of growth. To what extent the values of the coefficient may be a measure of the relative nutrient efficiency of any salt, or may be determined in terms of temperature or of the summation of atmospheric factors, i. e., character of climate, and how far they hold out the promise of being a standard, mathematically-expressed index under soil, seasonal, and plant variations, and how far the range of deviation and the minimum value will enable in detecting physiological limits to plant processes, to morphogenesis, to geographic distribution, or to zonation in montane regions, remains to be determined. The problem is decidedly complex. It is not the purpose of the present paper to enter into this phase of the discussion, but rather to confine itself more closely to the relation of transpiration to green and dry substance produced and to growth.

There can be little, if any, doubt that the absorbing power of the root system of a plant is not regulated by the amount of water transpired, but rather by the differential permeability of the absorbing epidermal root cells and the metabolic require-

ments during the life cycle. The phenomena of selective absorption show that transpiration does not determine in these cases the amount of salts absorbed during metabolism and growth, that the time of maximum absorption for different salts varies, and that they are absorbed at independently varying rates. Plants do not absorb mineral or organic constituents in the same concentration as exists in the solution in which the roots are found. The data from numerous experiments show that under certain conditions the roots of plants remove the solutes from a solution faster than the water, and in a different ratio than exists in the solution. The process of absorption of inorganic and organic constituents is not connected with transpiration, but with the metabolism of the plant. Hence, the value of the transpiration ratio is, under these conditions, more frequently inversely proportional to the amount of growth and the luxuriance of vegetation. The marked difference exhibited by different plants in efficiency of growth under conditions of limited water supply is particularly a characteristic and striking feature of variability in nutritive metabolism, not in transpiration. It is unnecessary to review such cases as include the action of mineral fertilizers—separately and as antagonistic or balanced solutions— the effects of organic compounds from peat and from mineral soils, the action of inorganic and organic acids and alkalies. Such investigations are well known. They are extremely important as they show that rapid production of green and dry substance of plants is not necessarily accompanied by a high relative or total transpiration value. The conditions of water loss show extreme variations with respect to the total quantity of water available and required, and the amount of growth.

Under the circumstances it is unnecessary to discuss the problem as to what special demands on inorganic materials individual plants may make, wherein the use or advantage for necessary essential and nonessential constituents lies, or to differentiate nutritive materials from those functioning otherwise. The specific effects produced by these substances, either externally or after having entered the cells and there reacting with the contents, differ according to the nature of the compound and if derived from habitat conditions characteristic of unrelated vegetation types, e. g., those frequenting organic soils, such as peat, may even interfere with growth and normal development. The specific physiological effects produced may be more marked on the roots than on the green parts of plants, or may affect leaf tissue more strikingly than that of the stem. These different reactions are due in part to modifying effects upon imbibition of cell colloids, largely to changes in the permeability of the protoplasmic membrane and in the metabolism accompanying the direct absorption of constituents in the soil solution. In

some cases an insufficiency of any salt will operate as a limiting factor, the plants continue to transpire and yet make little growth, or may even show a loss in weight accompanied by a high transpiration; in other cases the conditions retard or inhibit growth as well as transpiration and produce the effect of physiological drought; still other cases exhibit no detrimental effect, but rather an increase in growth and in yield of plant material with little or no change of transpiration; stimulation may accelerate or diminish the rate of transpiration, but not necessarily that of metabolism or growth. These phenomena have been shown repeatedly by the work in this laboratory (Bull. 16, 1912, Geological Survey of Ohio) and by the experimentation of various investigators elsewhere.

Variation in green and dry weight of plants and a great expenditure of energy often indicated by a loss in total weight, commonly occur during activity in spring while leaves are unfolding; the inequalities cannot be attributed to differences in rate or amount of transpiration. The greater absorption and distribution of mineral salts and organic material which has been reported under conditions of increased humidity, of shade, or at different periods of growth is not determined by an accelerating effect of the transpiration current. In autumn, following the death of leaves, when there is a relatively rapid migration of mineral and organic substances to other parts of the plant, it becomes obvious that the transpiration stream is not the medium by means of which a plant can obtain a better supply of the necessary nutrients. The translocation of organic or inorganic material to leaves, or from storage regions to places where they are used up, is a phenomenon of wide occurrence in aquatic plants, in underground parts of land plants, in plants occupying very humid and very dry land areas. Maximum growth is correlated with a large movement of materials, but the more vigorous translocation and absorption of salts and organic material can rarely be referred to a greater transpirational water loss or to a more vigorous transpiration current; the rate and the direction of the movement of the solutes and water is independent of one another. The causes of these phenomena are identical with those recorded for the selective absorption of roots. They are conditioned by the differential permeability of the protoplasmic membranes of cells, and are related and dependent upon the more complex metabolic influences of the entire organism. One can comprehend the advantage which plants with woody tissue have over those in which the movement is wholly in the cortex, but the reasons advanced in support of the transpiration view do not appear quite sound. A number of plants show "preferences" for lime soils in one part of their areal range which are not typical in another habitat. Others thrive,

successfully reproduce themselves and constantly extend their range of distribution largely because the various responses in vegetative characters or reproduction, in differences in abundance, in effectiveness of competition, are more frequently matters concerned with inherent vitality, with endurance and acclimatization, with the physico-chemical complex of the plant itself, rather than with favorable habitat conditions. As one travels into the interior of a continent the increasingly continental character of the climate is accompanied by the appearance, on the whole, of open and woody plant associations which do not show growth or the strong development of woody tissue as a response to the influence of greater amounts of transpiration water. As has been pointed out elsewhere by the writer, the scattered types of geographical distribution and the trend of the migratory movement of individual species and of associations tend more frequently to indicate the importance of functional plasticity and the nature of the invasion level, i. e., whether the plants become dominant, or enter as dependent species and either become assimilated with the vegetation type or are slowly exterminated. At all events the facts cannot be related merely by taking into account the transpiration current or the quantity of water evaporated. The rate and character of growth, the demand for materials and the destination of the migratory materials of various kind are conditioned usually upon the character of the constructive metabolism.

That no direct relation exists between growth, green and dry weight of plants and transpiration even under the same conditions of experiment is further illustrated by an examination of the quantity of water associated with metabolism. Water, in addition to its important physical influence in imbibition and turgor phenomena, has various other roles. In the living plant organisms are going on many chemical reactions within limited conditions of temperature and moderate concentrations of solutions. All these energy transformations take place in the presence of an excess of water within the plant. They come to an equilibrium point or to an end by the dilution or removal of the products of the reaction; the velocity of these reactions is regulated by the general physical factors governing such changes within a colloidal system. The most important reactions upon which the life and the growth of plants depend are those by which water is held and fixed in organic combinations (1) in the synthesis of food and body material, and (2) in hydrolytic reactions whereby water unites with insoluble carbohydrates as well as with fats and proteins to form diffusible products for translocation to active cells and to the growing region.

The quantity of water combined in synthetic reactions is fairly well known. Assuming that as much water is set free in the breaking

down as is fixed in the construction of these materials, i. e., that the complete oxidation results in a quantity of water equal to that required during photosynthesis and chemosynthesis, the amount of water comprises but little more than three-fifths or 60 to 65 percent. of the weight of the dry matter of plants. The ecological water requirement it will be seen is greatly in excess of the actual quantity of water used; the quantity of water lost by transpiration is not related to the synthetic process. Transpiration aids the gaseous exchange, but the rate and amount of CO_2 entering is not in proportion to the water evaporating through the stomata. The diffusion of the gas is independent of it, and the supply of CO_2 is usually less than could be utilized by the chloroplasts. The results obtained in green and dry weight of plant depend upon and vary within the limiting conditions of the CO_2 gradient in the air, the light intensity, and the general temperature conditions as well as the duration of period of the growth.

Unfortunately the number of investigations on hydrolytic reactions in plants during their entire life cycle is small, and it would be therefore unsafe to make any extended discussion of the results. The greater percentage of organic matter in tissues is often due to hydrolytic reactions, but the total quantity of water used in this manner is unknown, since no means are yet available for the determining the extent and the degree of hydration, and the number of times which degradation or metabolic transition products function in hydrolytic reactions. In many cases the action consists merely in an absorption of water which is followed by a splitting up of the substance. The different hydrolytic enzymes which act upon glucosides, and such catalytic agents as saccharase, amylase, cytase, lypase, protease are active in this stage of metabolism. In other stages the hydrolytic processes are reversible and accelerate synthetic combinations, some of the products showing profound differences in reaction and with relation to the influence of external factors. The number of such intermediate compounds is large; their molecular structure is not sufficiently well known, and the knowledge of this construction action is yet very scanty. Hydrolytic reactions occur in all stages of growth, from germination to maturity and decay.

The attention of physiologists has been attracted thus far especially to the dependence of these reactions on temperature. However, the principle of temperature coefficients fails to hold rigidly, for wherever components are co-ordinated into a system of reciprocal relations, and obscured by the effects of limiting conditions, such as in the cycle of changes collectively spoken of as growth, the character and the rate of any one single reaction is not that of more elementary chemical processes. Beyond a certain point, further temperature increases do not cause more growth. The favorable range of temperature has not as yet been

correlated with the various functions of a plant or of different plants. On the other hand, plant temperature follows very closely that of the environment; hence, it seems likely that the effectiveness of temperature conditions upon the general development and growth of plants, from the time of germination to that of seed maturation, and the limits of temperature requirement (for morphogenesis and for plant distribution as well) may be measured. Indeed, values have been obtained in various ways and used as a fairly approximate criterion. But much needs yet to be determined empirically. Inquiries of the highest importance concern the relations between reaction activities and the regulative functions, and their degree of interdependence. A compact sturdy growth and a greater yield in seed can be obtained in most plants only over a comparatively restricted range of temperature, and hence only over a limited geographical range, if the water supply increases. Differences in the ability of species or of associations of plants to grow under conditions widely different from those of their typical habitat and thus the increase of their areal range, again point to the limit finally set by the relative ability of the protoplasmic functions in acclimatization or competition.

It seems to be known only in a general way that the greater the proportion of the water component in the plant, the nearer is the equilibrium point to the position of complete hydrolysis, thus affecting the concentration and the character of the food materials. It is well enough known that an increased water supply prolongs the vegetative period of growth and increases the forage value of the crop rather than the yield in grain, and that the less water used in growing grain, the greater is the percentage of gluten in the seed and the higher the food value. In recent years the tendency all over the western United States is toward a more economical use of water, even in localities where water for irrigation is still reasonably low in price. In the east correlation studies have been made between rainfall and the yield for a number of agricultural crops. The data indicate a general relation between yield and the water supply during the months of July and August,—during the intermediate period of active growth when the plants are undergoing hydrolytic changes in metabolism preparatory to building up seeds and fruit. A greater water content within the plant is required during this period for such purposes than is needed during germination or ripening or at any other stage in growth, and the danger of impairing the vitality of the plant is greater at this time if it lacks this physiological water requirement. It must be present in a certain minimum quantity before maturity and ripening can take place; otherwise the ripening processes are retarded and growth results in a small yield, in dwarfing of the whole plant, and in injuries when the maximum

quantity of water is exceeded. The entire structure of land plants inhabiting dry climates shows the resistance to transpirational water loss and how far such limitations may go; and the plants possessing special body features for accelerating transpiration or for exuding water where transpiration is out of the question, indicate how fundamentally important is the maintenance of the water balance within the plant. Artifical defoliation, an increased water supply or decreased transpiration are known to affect in a number of trees the thickening of cell walls during the formation of autumn wood; this is caused partly by inferior nutrition, largely by the increased amount of water in the plant. The dearth of both exact knowledge and laboratory experiment make it impossible to state the amount of water involved in hydrolytic reactions and necessary as a constant quantity in the plant during its life cycle for vegetative or reproductive growth.

It will be seen from the brief remarks above that the rate of growth, the amount of it and the final size attained by a plant depend in part on favorable conditions of temperature, light intensity, food supply, and on the amount of water present in the plant. The rate or the total amount of water transpired gives no indication as to the quantity which normally is required for metabolic processes and for growth. Moreover, the chemical reactions associated with the growth of cells throughout the formative phase, the phase of enlargement of cells and that of maturation, by which food materials and other substances become incorporated into body tissue, are largely dehydrating in character. At the growing point it is chiefly a local production of originally combined water set free by dehydration processes and by respiration rather than the transpiration water which induces turgor and the elongation of new cells. Many plants, aside from those carrying water in a special storage tissue, are able by means of dehydrating processes to withstand long periods of drought without permanent injury; and numerous cases are known of fruits, seeds and severed portions of living plant tissue which are able to maintain a certain quantity of intracellular water in this manner indefinitely, and for some time a constant loss of water incurred through transpiration.

It would certainly be quite wrong to conclude that transpiration is not essential to plants, merely because it is not directly related to absorption and translocation of solutes, to green and dry weight of plants, and not a measure of metabolism and growth or vegatative luxuriance. The quantity of transpiration water in most plants is certainly not co-ordinated with or related to these functions. The retention of water is the physiological function indispensable to growth in general, and to survival and greater areal distribution in regions of a continental climate. But there can be no doubt that transpiration is indicative of

the water relation of diverse habitats and diverse plants. The incidental advantages associated with transpiration are undoubtedly these: the water loss reduces the temperature of the plant itself to that of the air about it, thus preventing injury by overheating in direct sunlight; and it aids in the gaseous exchange. The significance of transpiration as one of the forces which bring about the ascent of water in plants cannot be ascertained as yet. Data required for the solution of the question are wanting. Other forces must be involved to effect, in humid areas or during periods of defoliation, the lifting of water in the stem to a certain height, and in sufficient quantity. Transpiration may be to a certain extent a factor in determining the form of the plant. The variability especially of the higher plants in growth form and in anatomical structure has been shown to be far greater in this respect than hitherto supposed; among all the agencies that affect shape and structure in the plant none has more formative influence than water. But here also critical researches are still required to determine how far differences in the requisite water content of the plant—the water equilibrium of the entire plant—rather than differences in the rate or the amount of transpiration are the causal conditions. The examination of these relations must be more quantitative than has heretofore been attempted to be of value to scientific agriculture and to plant geography.

AN OCCURENCE OF ATYPUS MILBERTI WALCK. IN OHIO.

Carl J. Drake.

While working on the food of frogs at Cedar Point, Ohio this summer I found in the stomach of Rana pipiens Shreber the rare purse-web spider, Atypus milberti Walck. This is the first record of its occurence in the Central States and the second time it has been taken north of Washington, D. C. The frog was caught August 15, about one and one-half miles southeast of the Lake Laboratory, close to Sandusky Bay.

Prof. W. M. Barrows recognized the spider as Atypus and sent it to Dr. Banks at the National Museum, who sent the following reply: "This is the Atypus milberti Walck. as you suspect, and far north for it. Last summer Emerton took one half way up the Hudson River. The high cost of living is evidently not affecting frogs, when they take such rare thing as Atypus."

FLOOD EROSION ALONG PAINT CREEK, FAYETTE COUNTY, OHIO.

Charles W. Napper.

A little more than two miles above Greenfield, Ohio, a crossroad connects the Washington C. H. and Good Hope Pikes that have run parallel for that same distance on the eastern and western sides of Paint Creek. This cross road traverses the creek by what is known in this locality as the First Iron Bridge.

At this place Paint Creek is a rather deep stream flowing in a well-defined bed with a distinct flood plain on either side. The soil of this plain is thin, and in many instances the underlying rock, the Greenfield dolomite, comes to the surface and projects into the creek.

Fig. 1. General view of cut from the southern end.

For a short distance above the Iron Bridge, Paint Creek runs due north and south. Below the bridge a rocky ledge causes it to swing to the eastward. As is usual in stream life, when bends are made, the stream will endeavor to straighten its channel under certain favorable conditions. In the instance we are describing these favorable conditions came with the high waters that prevailed over southern Ohio in the latter part of March, 1913.

At this time Paint Creek rapidly rose to its highest stage and completely filled and covered its entire flood plain. The cut made by the stream where it broke out of its accustomed channel has a mean measurement of 350 feet long, 47 feet wide, and 6 feet deep.

At the extreme southern end it terminates by narrowing into a small, shallow gulley, a foot wide. The sides are perpendicular and appear as if trimmed by hand as is shown in the photograph.

Fig. 2. Exposure of the cut wall and the dolomite.

The walls show characteristic glacial drift overlain by a thin, black soil. Beginning at the northern end for nearly half the length of the cut all the material has been removed down to the Greenfield dolomite.

Fig. 3. Re-deposited drift in the pasture.

On the uppermost layer of the limestone are seen splendid striations. In places the rock surface is worn smooth, polished, and clearly striated. The striae run in a northeastward direction. The exposure shows the thin, rough, undulating, uneven bedding of the upper layers of the Greenfield dolomite. The beds dip rapidly to the southwest and pass under the overlying drift about the middle of the cut. There is an interval of possibly 30 feet between the southern end of the cut and the place where the

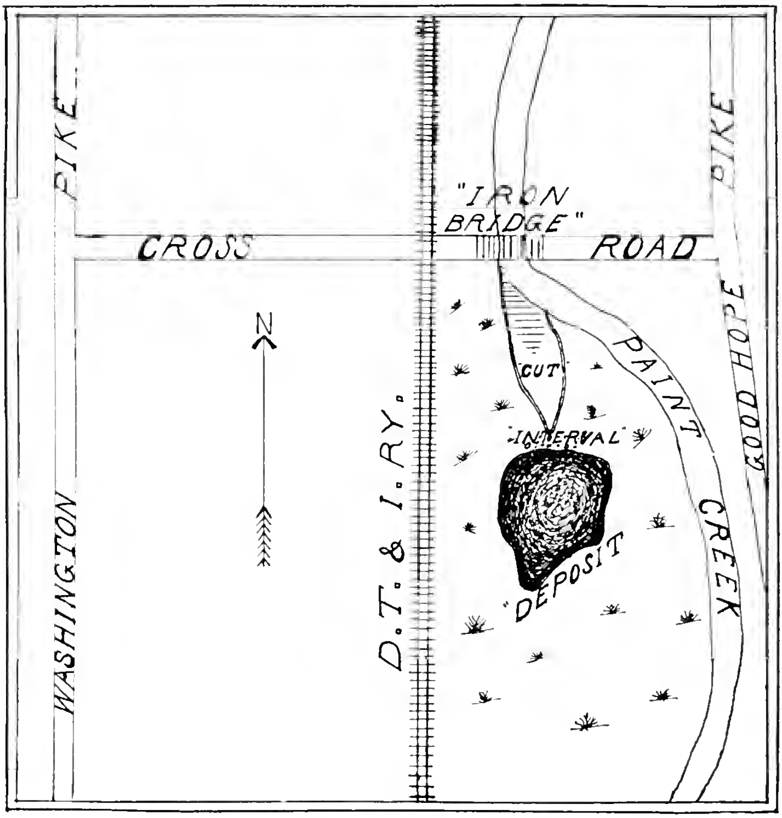

Fig. 4. Map of the Paint Creek cut.

material was deposited. This interval is free from deposits except some very large glacial bowlders. Some variation in the velocity of the stream held the material in suspension only to drop and spread it out lower down. The re-deposited drift material is spread over a heavily sodded pasture to a thickness of three feet, covering a space 350 feet long and 100 feet wide. Comparing

measurements it will be seen that the deposit is the same length, about twice the width, and one-half the depth of the cut. Therefore this material will fit in the excavation already described.

The deposit has been washed clean and stands out in very strong contrast with the sod on which it has been laid. An examination of the material shows igneous, metamorphic, and sedimentary rocks mixed in hopeless confusion.

The top layers of the Greenfield dolomite were loose and shattered in many places. The force of the water tore away slabs of this rock and carried them along with its load of drift. Hence in the deposit finely glaciated pieces are to be found.

From the sketch it can be seen that the deposit extends toward the southwest. This results from a gulley running beside the railroad track which served to maintain the water volume and velocity.

ECOLOGICAL VARIETIES AS ILLUSTRATED BY SALIX INTERIOR.

John H. Schaffner.

The recent advances in our knowledge of fluctuations, mutations and Mendelian phenomena of inheritance have given a new conception of the nature of a species and its subordinate groups. It is perfectly clear to any one who has studied Mendelian phenomena that no individual can contain all of the characters present in our ordinary species and that no description of a species based on a single individual is adequate. The description of a type individual is no doubt desirable to fix specific names, but it should be regarded as the description of the individual which may or may not give a fairly reliable picture of the species to which it belongs.

The fact of necessary fluctuation is firmly established and it is quite evident that no amount of selection of a fluctuating unit will advance or degrade the character involved. There are, however, fluctuations or adaptations related definitely to the environment which still present one of the important and fundamental problems of biology. The fluctuation induced by environment may be quantitative or qualitative. In mere quantitative fluctuation there may develop enormous differences between individuals of the same variety or species. For example, in the wild variety of the western Helianthus annuus, the mature plant may be 3 inches high with a single small head at the top or it may be 17 feet high with a multitude of branches and heads, with a corresponding thickness of stem. In various species of plants belonging to different orders, the individual may develop as a tall, strictly erect plant in one environment and in another may assume a perfectly prostrate, mat form.

The fluctuation I wish to call attention to is of a somewhat different character and involves morphological peculiarities of form and quality. The common sandbar willow, Salix interior, is typically a rather smooth plant with long linear lanceolate leaves. For several seasons I have had this plant under consideration at Cedar Point, Ohio, and last summer collected a series of forms ranging from the water's edge on the bay side to the dryest sand dunes and blowouts on the lake side. There is a perfect gradation from nearly glabrous plants at the water's edge to very white-hairy individuals in the hot dry sand, and from the long linear-lanceolate leaves of the hydrophytic plants to the long oval-lanceolate leaves of the individuals growing in the extreme xerophytic conditions. The latter form has been called Salix wheeleri, being regarded by some as a species and by others as a variety. When one compares the two extremes, there is a most striking differences—a much greater difference than exists between a very larger number of recently manufactured species. Now why is there such a gradation from plants growing in one extreme to the other? The final answer cannot be given until breeding experiments are carried on. It might be mentioned that carpellate plants are more abundant in the wet soil while the dry sand plants are nearly all staminate. The observations in the field indicate that the individual responds in its growth to its environment. Either the same hereditary factors can respond so as to produce diverse structures or there are factors latent under one set of conditions and active in another. If a complex hereditary constitution is involved it should be possible to segregate at least part of the factors involved and thus establish distinct, pure varieties which would no longer be able to respond in such an extreme manner. But if, as is probable in this case, it is merely the response of factors to a greater or less degree to environmental causes, during growth, than no such segregation could be brought about. Whether the one or the other extreme could be established as a permanent, hereditary variety would depend on whether it is possible to produce hereditary responses of the same nature as are shown in the individual response during growth. This is an open question far from being settled at the present time. There is no object in asserting the one or the other hypothesis. But so far we have no direct evidence that the individual response can influence the hereditary constitution thru which it acts. It is important, however, to recognize the reality of the diversity of individual response leading to individual adaptation to the environment. Some who have speculated along these lines have evidently not had a very thoro systematic and morphological knowledge of the plants in the field with which they were dealing.

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THE FOOD OF RANA PIPIENS SHREBER.

CARL J. DRAKE.

The frogs, Rana pipiens Shreber, dissected for this paper were collected on the peninsula of Cedar Point, Ohio, at various times during the day and evening, between August eighth and August twenty-second inclusive. My notes are entirely derived from the two hundred and nine specimens collected here in the low, wet depressions between the sand dunes, in the weeds and grasses southeast of the Lake Laboratory, and one evening under the electric lights at the Summer Resort.

The object of this paper is to determine the food of our common leopard frog, Rana pipiens Shreber, and its relation to nature in the neighborhood of its habitat. Owing to the fact that the frog's skin must always be kept moist in order that cutaneous respiration may take place, its habitat is always in close proximity to water, or among wet weeds and grasses. Water also affords the means of escaping from its enemies; one who walks along the margin of a pond or stream will notice that a frog when startled almost invariably makes a jump for the water. In this way the creature has a ready mode of escaping, not only from man, but from any other creature which might easily overtake it in an open field.

The frog's food consists of almost any kind of an animal small enough to be seized and swallowed. It has an instinct to snap at all moving objects that come sufficiently near, and will not take dead or motionless animals. Only living and moving creatures are devoured. The frog's tongue is the only organ used for seizing food. It is soft, extensile, attached in front, but free behind,

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Animals	6	5	3	†	2	1	5	2	[illegible]	[illegible]	[illegible]	1	5	4	1	10	1	2	10	5	2	1	4
Mollusca							3												1				
Crayfish																							
Spiders	1		1				2		3	3										4		1	1
Insects	5	5	2		2	1	3	2	4	4	3	1	5	4	1	10	1	2	9	1	2		3
Ephemeridae							1				2		4										
Zygoptera																			2				
Acrididae			2				1								1								
Gryllidae		1						1															
Gerridae							1		1							6	1	2			2		
Membracidae		1																					
Caterpillars	4								1	1													1
Coleoptera		1			2	1		1	2	3	1	1	1	4		3			[illegible]	1			2
Carabidae		1			1						1		1	4		2			4	1			2
Coccinellidae						1						1											
Staphylinidae																							
Spondylidae					1																		
Rhynchophora								1	2	5						1			3				
Beetle Larvae																							
Formicina	1	2														1							
Ichneumonidae																							

Frog Number	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Animals	2	3	12	[illegible]	3	7	5	7	5	4	4	5	5	4	3	4	5	4	2	1	5	4
Mollusca																						
Crayfish																			2			
Spiders		1	2	6	1	3	2	1		2	3		2	3	2	3	2	2			1	1
Insects	2	2	5	2	2	4	3	6	3	2	1	5	1	1	1	1	3	2			4	3
Ephemeridae			2																			
Zygoptera												2										
Acrididae																						
Gryllidae																	1					
Gerridae																						
Membracidae									1													
Caterpillars	1			1	1	1	1	2	1	1				1			1	1			3	2
Coleoptera	1	2	3		1	3	2	3	1	1		3	1		1	1	1	1			1	1
Carabidae								1														1
Coccinellidae												1									1	
Staphylinidae	1																					
Spondylidae																						
Rhynchophora		2	[illegible]		1	3	2	1	1	1		2	1		1	1	1	1				
Beetle Larvae								1														
Formicina											1											
Ichneumonidae				1				1														

† This stomach was entirely empty.

‡ This stomach contained sand only.

Collected Aug. 8, 1913, between 2:00 p. m. and 6:00 p. m., also between 8:00 p. m. and 10:00 p. m.

and covered with a sticky secretion which adheres firmly to the food seized. So rapid is the protrusion of this weapon that a careful watch is necessary in order to see the animal feed.

The material contained in the stomachs examined can be divided into two classes, animal and foreign. All the evidence indicates that the presence of substances other than those of an animal nature is merely incidental, and due to the mode and conditions of feeding.

Foreign Matter. Nothing can be more natural, since the frog captures the greater part of its prey on the ground by means of its tongue, than that a small amount of foreign substance should be swept into the mouth along with the animals upon which it feeds. In the stomachs examined, this foreign substance

LOT II

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Animals	5	8	9	3	2	12	7	6	6	9	6	2	9	2	3	6	18	11	8	7	2
Mollusca		1	1														2	1	1	1	
Isopoda							1		1	1									1	1	
Spiders	2	2	4	1		4	2	3		2	4		4	1	1	3	4	4		1	
Insects	3	5	4	2	2	8	4	3	5	6	2	2	5	1	2	3	12	6	6	4	2
Acrididae																			2		
Gerridae	1														1	1			1	3	
Membracidae									1				1						1		
Caterpillars		2	2	1	2	4	2			5	2	1	2	1				5			1
Coleoptera	2	3	2	1		4	2	3	4	1		1	2		1	2	11		2	1	1
Carabidae						1				1					1	2	3			1	1
Staphylinidae		1															2				
Rhynchophora	2	2	2	1		3	2	3	4			1	2				3		2		
Beetle Larvae																	3				
Formicina																	1				
Bembecidae																		1			

Collected Aug. 11, 1913, between 2:00 p. m. and 3:30 p. m.

consisted of vegetable and animal matter. Very little vegetable matter was found. In four stomachs, it consisted of bits of rotten wood, in eight stomachs, seeds of Washingtonia claytoni Britton, in two stomachs, pieces of linden leaves (Tilia americana L.), and in two stomachs, a little spirogyra, the latter being found in stomachs containing aquatic insects. The mineral matter, which consisted of pebbles and sand, composed the greater part of the foreign material. Four small pebbles were found in four stomachs, and about fifteen per cent of the stomachs contained sand, three being completely filled with the latter only. Almost invariably, in the stomach containing sand, the frog had been feeding or preying on animals found on the ground. As the frog swallows its prey entire and the stomach does the whole process of trituration, it is probably that the sand aids in grinding the animals, especially insects like beetles with hard chitinous bodies.

LOT III.

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Animals	4	2	7	4	4	1	3	5	5	5	3	2	3	1	5	7	2	4	7	4	3	4	8	10	3	†	6	5	6	8	2
Mollusca			1		1				1												1			3					2		
Isopoda																								1			2			1	
Spiders	1		4	2				2		2	1	2						2	3			1		1			2	1	1		
Insects	3	2	2	2	3	1	3	3	4	3	2		3	1	5	7	2	2	4	4	2	3	8	5	3		2	4	3	7	2
Pentatomidae			1																												
Membracidae								2								2															
Chrysalis					1																										
Caterpillars	2	1		1	1	1	1		1	2			1	1	1	2	1			1	2	2	1	1				1		4	1
Coleoptera	1	1	1	1	1		2	1	1	1	2		2		4	1			2	3		1	6	3	3		2	3	3	3	1
Carabidae			1	1	1			1							4								3		1			3		3	
Coccinelidae											1													1	1						
Staphylinidae										1																					1
Chrysomelidae							1																		1						
Rhynchophora		1					1		1		1								2			1	2	2			1				
Beetle Larvae	1																						1				1		3		
Formicina									2								1	1	2				1	1							
Bembecidae																2		1													

† This stomach was entirely empty.

Collected Aug. 12, 1913, between 2:00 p. m. and 4:30 p. m.

Since the greater number of stomachs contained no sand, and since, as a rule, sand was found only in stomachs containing ground animals, I am inclined to think that its ingestion was merely incidental.

LOT IV

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Animals	2	1	1	2	1	‡	4	2	3	2	2	2	3	4
Spiders		1	1	1	1		2	1	3	2		2	1	3
Insects	2			1			2	1			2		2	1
Acrididae													1	1
Membracidae				1							1			
Caterpillars	2						1							
Coleoptera							1				1		1	
Cicindelidae											1		1	
Rhynchophora							1							
Pompilidae								1						

‡ This stomach contained sand only.

Collected Aug. 13, 1913, between 4:00 p. m. and 5:00 p. m.

LOT V.

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Animals	6	7	3	5	6	6	5	5	4	5	2	2	5	3	3	1
Mollusca					2			1								
Myriapodo														2		
Spiders	3	4	2	3	2		1		2	2	2		1			1
Insects	3	3	1	2	2	6	4	4	2	3		2	4	1	3	
Acrididae		1					1							1		
Caterpillars		1			1	3	1	1	2			1			1	
Diptera					1											
Coleoptera	2	1	1	1		1	2	3		3		1	2		2	
Carabidae		1		1			1	1								
Cicindelidae						1				1						
Rhynchophora	2		1				1	2		2		1	2		2	
Formicina	1			1		2										
Bembecidae													2			

Collected Aug. 15, 1913, between 10:30 a. m. and 1:00 p. m.

Animal Matter. The frog's food consists of mollusks, crustaceans, myriapods, spiders, and insects; in fact any sort of living creature is acceptable to it as both sense of taste and of smell are apparently obtuse. In a few stomachs, a small amount of

LOT VI.

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Animals	2	2	3	3	1	3	1	‡	5	4	2	2	3	‡	3	9	2	4	4	4	2	3	3	2	‡	2	5
Mollusca										1												1				1	
Spiders	1		1	2	1	3			3			1						2	2			2		2			1
Insects	1	2	2	1			1		2	3	2	1	3		3	9	2	2	2	4	2		3			1	4
Acrididae	1											1															
Gryllidae											1							1									
Membracidae							1								1											1	
Neuroptera																			1								
Caterpillars																							2				
Diptera													1														
Coleoptera		2	1	1					2	3	1		2		2	9	1	2		4	2		1				2
Cicindelidae																9				4							
Carabidae		2		1					2	1							1	1									
Rhynchophora			1							2	1		2		2			1			2		1				2
Ichneumonidoe																			1								1
Vespidae			1																								

‡ This stomach contained sand only.

Collected Aug. 16, 1913, between 11:00 a. m. and 2:30 p. m.

partially digested animal matter was present that could not be placed in its proper phylum and I will make no further reference to it.

Acknowledgment. I wish to express here briefly, my sincere appreciation to those who have very kindly assisted me in the determination, as follows: Prof. W. M. Barrows and Mr. W. J. Kostir of Ohio State University, the spiders and the Orthoptera; Prof. Stephen R. Williams of Miami University, the Myriapoda; Mr. Chas. Dury; the Rynchophora; and to Doctors Harriet Richardson, A. K. Fisher, and J. C. Crawford of the National Museum, Washington, D. C., the Isopoda, the Lepidopterous larvæ, and the Hymenoptera.

LOT VII.

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Animals	6	‡	5	5	2	13	7	5	5	3	5	2	4	2	3	2	7	2	2	‡
Mollusca											1									
Isopoda	6												2							
Spiders			3	2	2	3		2	2	1	2				1	1	2	1	1	
Insects			2	3		10	7	3	3	2	2	2	2	2	2	1	5	1	1	
Gryllidae				1																
Acrididae										1			1	1					1	
Caterpillars						7	2						1	1	1		2			
Diptera									1									1		
Coleoptera				2		2	5	3	2	1		2			1	1	3			
Carabidae						1	3	2		1					1		3			
Cicindelidae							1	1	1			2								
Coccinelidae						1			1											
Cerambycidae							1													
Rhynchophora				2												1				
Tenthredinidae			1																	
Formicina			1			1					2									

‡ This stomach contained sand only.

Colleeted Aug. 18, 1913, between 10:00 a. m. and 1:00 p. m.

MOLLUSCA.......................................29

Gastropods furnished three per eent of the entire number of animals and were found in ten per eent of the stomachs examined. In a few stomachs, the digestive fluids had dissolved the shell beyond recognition. The speeies that eould be identified were:

Limacidæ.......................................3

Zonitoides arboreus Say.......................................3

Strepomatidæ.......................................5

Goniobasis informis Lea.......................................5

Limneaidæ.......................................11

Galba humilis modicella Lea.......................................4

Physa heterostropha Say.......................................7

Gastropoda, not further identifiable.......................................10

LOT VIII

Frog Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Animals	3	1	6	†	12	17	3	2	8	6	4	5	5	‡	9	3	8	10	10	1	2	24	1	4	3	30	2	6	6	4	3	4	3	7	7
Mollusca						1																1													
Isopoda						10	1		2				4					2				22				27									
Myriapoda						1																													
Spiders		1			1			2	4	2	1	2			1		6	6	5		1	1			1		1		2						2
Insects	3		6		11	5	2		2	4	3	3	1		8	3	2	2	5	1	1		1	4	2	3	1	6	4	4	3	4	3	7	5
Zygoptera					1																														
Blattidae							1													1								1							
Notonectidae										1																									
Butterfly																					1														
Caterpillars	2		2		1								1						2																
Diptera					1														3							1		4	2						
Coleoptera	1		1		6	5	1		1	3	3	3			7	3	2	2					1	3	2	2			2	4	3	4	3	7	5
Cicindelidae					2		1				3	1			5										2							2			
Carabidae						3			1							2		2											1	2			2	3	3
Hydrophilidae																																	1		
Staphylinidae						1																				1									
Coccinellidae																								2											2
Erotylidae																										1									
Elateridae	1																																		
Spondylidae																	1																		
Cerambycidae																															3				
Tenebrionidae			1																																
Rhynchophora					4	1				3		2			2	1	1						1	1					1	2		2		4	
Formicina					2																						1								
Bembecidae			3						1						1									1				1							

† This stomach was entirely empty. ‡ This stomach contained sand only.

Collected Aug. 22, 1913, between 9:30 a. m. and 2:00 p. m.

CRUSTACEA 87
Astacidæ 2
Only two crayfish were found, these were in a large frog caught in Beimiller's Cove.
Cambarus sp. 2
Isopoda 85
Members of this suborder, commonly called "sow bugs," form about ten per cent of the animals, twenty-seven being in a single stomach.
Oniscidæ 85
Porcellio scaber Latreille 2
Porcellio rathkei Brandt 47
Isopoda, not further identifiable 36

MYRIAPODA 3
Lithobius forficatus L. 2
Geophilus rubens Say 1

ARACHNIDA 249
Spiders were found in one hundred and nineteen stomachs and constitute about twenty-seven per cent of the entire number of animals. Their bodies are so extremely soft and fragile that in many stomachs they were ground up beyond specific recognition and only a few specimens could be identified.
Theraphosidæ 1
Atypus milberti Walck.* 1
Clubionidæ 1
Trachelas tranguilla Hentz 1
Lycosidæ 6
Lycosa sp. ♂ 2
Lycosa sp. ♀ 1
Lycosa sp. ♂ (young) 1
Pardosa sp. (young) 2
Epeiridæ 3
Metepeira labyrinthea Hentz ♂ 2
Meta menardi Latreille ♀ 1
Spiders, not further identifiable 238

INSECTA 563
Insects composed over sixty per cent of the total number of animals and were present in the stomachs of one hundred and seventy-eight frogs. Twenty-five per cent of the frogs had eaten nothing but insects. They are represented by nine orders: Ephemeridæ, Odonata, Orthoptera, Hemiptera, Neuroptera, Lepidoptera, Diptera, Coleoptera, and Hymenoptera.

* Ohio Nat., **14:** 251.

Ephemerida 9

Only nine mayflies were found; these were in the stomachs of four frogs taken one evening under the electric lights at the Summer Resort.

Ephemeridæ. 9
Hexagenia sp. 9

Odonata (Zygoptera) 4
Agrionidæ. 4
Argia sp. 4

SUMMARY

Lot Number	1	2	3	4	5	6	7	8	Total
Stomachs Examined	45	21	31	14	16	27	20	35	209
Animals	187	141	133	29	68	74	80	219	931
Mollusca	4	7	9		3	3	1	2	29
Crayfish	2								2
Isopoda		5	4				8	68	85
Myriapoda					2			1	3
Spiders	58	42	25	18	23	21	23	39	249
Insects	123	87	95	11	40	50	48	109	563
Ephemeridae	9								9
Odonata	4							1	5
Orthoptera	7	2		2	3	4	5	3	26
Hemiptera	15	10	5	2		3		1	36
Neuroptera						1			1
Lepidoptera	24	30	30	3	11	2	14	9	123
Diptera					1	1	2	11	15
Coleoptera	57	43	49	3	19	35	22	74	302
Hymenoptera	7	2	11	1	6	4	5	10	46

Orthoptera 26
Blattidæ. 3
Blatella germanica Linn. 1
Periplaneta americana Linn. 1
Ischnoptera pennsylvanica DeG. 1
Acridida. 17
Melanoplus differentialis Uhler. 2
Melanoplus femur-rubrum DeG. 12
Conocephalus (Xiphidum) sp. 3
Gryllidæ. 6
Gryllus pennsylvanicus DeG. 6

Hemiptera.......... 36
Notonectidæ.......... 1
Notonecta undulata Say.......... 1
Gerridæ.......... 20
Gerris marginatus Say.......... 20
Pentatomidæ.......... 1
Cosmopela cornifix Pen.......... 1
Membracidæ.......... 14
Ceresa bubalus Say.......... 14

Neuroptera.......... 1
Myrmeleonidæ.......... 1
Myrmeleon immaculatus De Geer.......... 1

Lepidoptera.......... 123

Insects of this order were found in the stomachs of seventy-three frogs, consisting of one imago, one chrysalis, and one hundred and twenty-one caterpillars. These larvæ were eaten indiscriminately and constitute one of the most important foods. Such hairy caterpillars as the larvæ of the Tiger-moths and Fall Web-worms were present in several stomachs. Frogs taken at night or in the morning contained such nocturnal larvæ as cutworms (Agrotinæ).

Lepidopterous larvæ are so easily digested that in many stomachs they were ground up beyond specific recognition and could not be identified beyond the family.

Pyromorphidæ.......... 1
Harrisina americana Guer.-Men.......... 1
Pyralididæ, not further identifiable.......... 9
Geometridæ, not further identifiable.......... 14
Notodontidæ.......... 28
Datana ministra Drury.......... 16
Datana sp.......... 12
Noctuidæ.......... 39
Apatela sp.......... 5
Agrotinæ (cutworms).......... 11
Arsilonche albovenosa Goeze.......... 2
Catocala sp.......... 7
Plusiodonta compressipalpis Guenee.......... 2
Noctuidæ, not further identifiable.......... 11
Arctiidæ.......... 28
Hyphantria cunea Drury.......... 1
Arctiidæ (chrysalis).......... 1
Arctiidæ, not further identifiable.......... 11
Sphingidæ.......... 1
Hemaris thysbe Fabr.......... 1
Hesperiidæ.......... 2
Eudamus tityrus Fabr.......... 2
Nymphalidæ.......... 1
Euvanessa antiopa Linn. (Adult).......... 1

Diptera...15
Tipulidæ, not further identifiable (larvæ)..................1
Muscidæ...12
Chrysomyia macellaria Fabr...............................4
Musca domestica Linn.................................8
Dipterous larvæ, not further identifiable.................2

Coleoptera......................................302

The beetles found, belonged to fourteen different familes and were present in the stomachs of one hundred and thirty-five frogs, eleven being found in a single stomach. They constitute thirty-three per cent of the whole number of animals and fifty-four per cent of the insects.

Coleoptera Genuina..................................176
Carabidæ..89

Carabids were found in fifty-two stomachs, composing about ten per cent of the animals. Because of their predaceous habits, these insects form a constant food for frogs.

Omophron americanum Dej.................................2
Bembidium variegatum Say.................................5
Callida punctata Lec.....................................4
Calathus gregarius Say...................................5
Platynus rubripes Zimm...................................3
Chlaenius sericeus Forst.................................1
Chlaenius impunctifrons Say..............................1
Harpalus pennsylvanicus Dej.............................68
Cicindelidæ..44
Cicindela punctulata Oliv...............................16
Cicindela hirticollis Say................................5
Cicindela repanda Dej...................................23
Hydrophilidæ.......................................1
Hydrophilus triangularis Say.............................1
Staphylinidæ.......................................8
Creophilus villosus Grav.................................8
Coccinellidæ.......................................13
Hippodamia 13-punctata Linn..............................4
Coccinella novemnotata Herbst............................1
Megilla maculata DeG.....................................8
Erotylidæ..1
Languria mozardi Lat.....................................1
Elateridæ..1
Alaus oculatus Say.......................................1
Spondylidæ...2
Parandra brunnea Fab.....................................2
Cerambycidæ..4
Leptosylus parvus Lec....................................4

Chrysomelidæ.....2
Calligrapha scalaris Lec.....1
Diabrotica 12-punctata Fabr.....1
Tenebrionidæ.....1
Only one of the darkling beetles was found. This has been pronounced by Mr. Dury as being a new record for Ohio.
Paratenetus gibbipennis Mots.....1
Staphylinidæ (larvæ).....4
Creophilus villosus Grav.....4
Beetle larvæ, not further identifiable.....6

RHYNCHOPHORA.....126
Weevils were taken from seventy different stomachs. The habit of these insects of dropping to the ground when disturbed gives the frog a chance to capture them.
Otiorhynchidæ.....120
Otiorhynchus oratus Linn.....120
Calandridæ.....1
Sphenophorus costipennis Horn.....1
Curculionidæ.....5
Sitones hispidulis Linn.....5
Beetle larvæ.....10

Hymenoptera.....46
Tenthredenidæ.....1
Cimbex americana Leach.....1
Pompilidæ.....1
Prioenemis alienatus Smith.....1
Ichneumonidæ.....5
Compoplex sp.....1
Glypta sp.....1
Itoplectis annulipes Br.....2
Itoplectis conquisitor Say.....1
Bembecidæ.....13
Microbembex fascieta Fabr.....13
Vespidæ.....1
Halictus sparsus Robt.....1

Formicina (Hymenoptera).....25
Componotus sp.....5
Formicina, not further identifiable.....20

TABLES. In the tables, the frogs are grouped into eight lots as collected and are numbered in the order of dissection. Under each frog's number, the animals found in its stomach are placed in their respective classes.

OHIO MOLLUSCA.

Additions and Corrections.

V. Sterki.

Since the preliminary catalogue of the Ohio Mollusca was published*, a good deal of collecting has been done, principally in northern Ohio, by Dr. R. C. Rush, John A. Allen, Calvin Goodrich, and myself. The fauna of the southern part of the State is still very insufficiently known, outside of the vicinity of Cincinnati, and the Ohio River, and in that, mainly the naiades. It is desirable that thorough, systematic collecting be done there, and also that at least one collection of the Ohio Mollusks be secured, as complete as possible, before it is too late. Then, a revised catalogue may be prepared.

Species and varieties added, up to the present time, are given in the following list, and also some alterations. A number of forms are doubtful; with more good material, their affinities may be ascertained. Additional localities of species enumerated in the catalogue, are noted only in a few instances.

The Naiades have been carefully studied by Dr. A. E. Ortmann, during the last years, and their arrangement and nomenclature have been changed considerably. These changes cannot be included here. Additional species and varieties of **Lymnæa,** and some changes, are cited partly from Dr. Frank C. Baker's monograph. The old generic name is retained.

Gastrodonta lasmodon, (Phillips), from Rootstown, are **G. suppressa** Say; "**G. suppressa,**" from Tuscarawas Co., are of an undescribed species, known also from Virginia.

Polygyra fastigiata (Say): Millville, Butler Co.! (t. Bryant Walker).

Philomycus biseriatus Sterki: Summit Co.! (Dr. R. C. Rush), Tuscarawas Co. (St.); distinct, or a var. of **carolinensis.** (Bosc.)

Bifidaria armifera similis Sterki. Kelley's Id.! (Allen).

B. armifera affinis, Sterki: dunes at Fairport (St.); Hartwell, Cincinnati! (Goodrich).

Vertigo pygmæa: (Draparnaud): Hudson, woods, and abundant in town lawns! (Rush).

V. pygmæa albidens Sterki (changed from **callosa,** preoc.), Columbus.

Succinea retusa magister Pilsbry. Lucas Co.! (Goodrich).

Lymnæa stagnalis appressa Say is the typical American form.

* Proc. Ohio State Acad. Sc., Vol. IV, Part 8, Special Papers No. 12, 1907.

Lymnæa columella casta Lea: Poland (type locality); Kent (Dean, St.).
Lymnæa sterkii Baker, is a var. of **parva** Lea, t. Baker.
Lymnæa dalli Baker, West of Cleveland! (Allen).
Lymnæa—modicella Say, is a var. of **humilis,** Say, not of obrussa, t. Baker.
Lymnæa humilis rustica Lea: Poland (type locality).
Lymnæa humilis Say, typical, is not in Ohio. t. Baker.
Lymnæa obrussa Say, has to take the place of **L. desdiosa,** Say, which is a var. of **palustris,** t. Baker.
Lymnæa elodes Say, distinct from **palustris,** Müller, t. Baker; various parts of the State.
L. elodes jolietensis Baker. Poland, Mahoning Co.; Akron (B. Walker); La Grange, Lorain Co. (B. Walker).
Lymnæa reflexa walkeri Baker. Near Cincinnati. (Lea).
Lymnæa exilis Lea, = **L. zebra,** Tryon, distinct from **L. reflexa** Say, t. Baker; Cincinnati; Poland, Mahoning Co.; pond near Congress Lake (Walker); Hudson (Rush).
Lymnæa kirtlandiana Lea, a distinct species, t. Baker; Portage Co. (Dean); Garrettsville, Portage Co. (t. Hinkley, Walker).
Lymnæa lanceata Gould. Hudson! (Walker, Rush); Lucas Co. (Goodrich.)
Planorbis trivolvis binneyi Tryon. Near Hudson, Summit Co.! (Rush); Mantua, Portage Co. (Allen); Lucas Co. (Goodrich).
Planorbis multilineatus Vanatta, appears to be not distinct from **dilatatus,** Gould.
Planorbis deflectus Say, needs revision.
Segmentina crassilabris Walker. Wood Co.! (Goodrich).
Vivapara contectoides W. G. Binney. A specimen is said to have been found in Sandusky Bay.
Campeloma integrum Say is a var. of **decisum** Say.
Ammicola letsoni Walker. Toledo! (Goodrich).—**Amn.**—"sp." is still undescribed.
Lampsilis ovata (Say) is a form, or var., of **ventricosa** Barnes.
Quadrula hippopœa Lea is a form of **undulata** Barnes, not of **plicata** Say.
Quadrula schoolcraftensis Lea appears to be distinct from **pustulosa;** Tiffin Riv. (Goodrich ,St.); Lake Erie at Toledo (Goodrich); Ohio River, rare (St.).
Quadrula pustulosa kleineriana Lea is a southern form, not in Ohio.
Sphærium simile Say must be **S. sulcatum** Lamarck.
Sphærium acuminatum Prime. Lake Erie at Toledo and Maumee Riv.! (Goodrich).
Sphærium ohioense Sterki. Ohio Riv. at Cincinnati (St.); also in W. Va. and Ind.

Musculium jayense Prime. Big Reservior, Summit Co. (Rush & St.); Midvale, Tuscarawas Co., rare (St.).

Musculium sphæricum Anthony. Authentic specimens are in the T. Prime collection, Mus. Comp. Zool., and in the National Museum. A small pond at Wooster (St.); pools near Geauga Lake, and west of Lorain (Allen).

Musculium parvum Sterki. Summit, Stark and Tuscarawas Cos. (St.).

Musculium "sp."=**rosaceum** Prime. Also: Mishler, Portage Co. (Allen); Hudson (Rush); Turkeyfoot Lake (St.); New Philadelphia (St.).

Pisidium minusculum Sterki. Navarre, Stark Co. (St.).

Pisidium regulare Prime. Cuyahoga and Geauga Cos. (Allen); Lucas Co. (Goodrich); Cincinnati (Anthony collection).

Pisidium subrotundum Sterki. Hudson (Rush, St.); ditch on Congress Lake (St.).

Pisidium tenuissimum Sterki. Turkeyfoot and Springfield Lakes (St.), rather different from the typical Michigan form.

Pisidium trapezoideum Sterki, in the catalogue, is probably a form of **P. neglectum.** (Typical **trapezoideum** is eastern).

INTRODUCED SPECIES.

Arion hortensis Ferusac. Storrs and Harrison's nurseries, Painesville (St.).

Stenogyra octona Chemnitz. Greenhouses at Painesville, and Akron (St.)

Lymnæa (**Radix**) **auricularia** Linne. Toledo! (Goodrich).

Field Manual of Trees by John H. Schaffner, is a convenient pocket manual for the study of trees at any season of the year. It includes in its area Southern Canada and the Northern United States to the Southern boundary of Virginia, Kentucky, and Missouri, westward to the limits of the Prairie. It contains among other things a key to the genera of trees in the summer condition; a key to the genera of trees in the winter condition; a general key to the families and genera based on the flowers; a key to the fruits and a general classification of the wood. A unique feature is the brief but distinctive characterization of each genus by vegetative characters. The publishers are R. G. Adams & Co., Columbus, Ohio. J. H. S.

SOIL BACTERIA.

M. C. Sewell.

To one interested in the manifold works of nature, the important factors concerned in crop production, and the maintenance of soil fertility, a resume of present day knowledge of soil bacteria, may well claim attention.

Scientists have demonstrated the presence of fossilized bacteria in the beds of ancient geological periods. We may then believe that long ages before man himself came to this earth, their existed microscopic forms of life, which found their food and energy in the destruction of organic matter.

The largest numbers of bacteria are found just beneath the first three inches of soil. From that point, with increasing depth, the numbers diminish, until at a depth of six feet but few bacteria exist. At the surface, bacteria are few in number because they are destroyed by snow and dryness.

Most bacteria require organic matter as a source of food, a certain degree of moisture, and a condition of aeration. The factors then influencing their growth are:

The character of the soil;

Tilth of the soil;

Percentage of moisture;

The reaction of the soil.

The pathogenic bacteria in the soil are present only temporarily. They do not increase in numbers and tend at all times to disappear, due to the lack of proper environment and the competition of soil bacteria.

The normal soil inhabitants are those which are particularly active with reference to nitrogen; carbon; sulphur; hydrogen; and iron.

Reaction of Bacteria to Nitrogen of the Soil.

Plants absorb nitrogen most readily in the form of a nitrate. To what extent they can absorb nitrogen in the form of amido-compounds we do not know. Nitrogen compounds are unstable. They are derived from organic sources, excepting such small amounts as may be combined by atmospheric electrical discharges and the larger amounts of ammonia vapor which some bacteria take from the air.

Four-fifths of the atmosphere is composed of nitrogen, so bacteria that can use this free nitrogen as it circulates with the air in the porespaces of the soil, have an abundant source.

There are present in the soil, two classes of bacteria, which, independently of green plants, absorb free nitrogen. They are nonsymbiotic and are unlike the well known leguminous bacteria.

One of these classes of nitrogen-absorbing bacteria is aerobic, requiring the presence of air in the soil. These bacteria are called Azotobacter. They require an abundance of lime, phosphoric acid, an optimum condition of moisture, and a soluable form of organic matter, namely, a carbohydrate.

The other classes of nonsymbiotic bacteria which absorbs free nitrogen, grows in the absence of oxygen, so is an aerobic. These bacteria are called Clostridium pastorianum. They are not as active nitrogen absorbers as the Azotobacter.

Azotobacter and Clostridium can both absorb nitrogen from other sources than the free nitrogen of the air. That is, if nitrates are abundant in the soil, then these bacteria will take their required nitrogen from this source. Bacteria contain some proteid material, as do plants, hence nitrogen is needed by them to build up proteid compounds.

Nature, when undisturbed in her processes, is able to maintain a sufficient supply of nitrogen in the soil by means of these absorbing bacteria. However, for man's improved cropping methods, the amount of nitrogen added by nature is not adequate.

Bacteria and the Decomposition of Soil Humus.

Soil humus is the decaying remains of plants which in their life process lacking in their body substance, large amounts of carbon, combined chiefly with oxygen, hydrogen, and nitrogen. All of these elements have been obtained from the atmosphere. Deposits of peat and beds of coal have likewise been formed from the atmospheric air. By the burning of peat and coal, carbon-dioxide is restored to the atmosphere. Other means of the restoration of carbon dioxide is the respiration of animals, of plants, and the production of carbondioxide by bacterial action in decomposition processes.

The organic matter in the soil furnishes food for bacteria and the bacteria in turn furnish food for green plants. Humus may be said to contain practically all of the combined nitrogen in the soil. An exception being the nitrogen contained in the bodies of free nitrogen absorbing bacteria. The term humus would include the nitrogen derived from the decay of leguminous plants.

While chemical changes take place in the process of decay and putrefaction, the process is biological in character. There would be no decay in the absence of bacteria and other micro-organisms.

Carbon.

In the form of carbon dioxide, carbon is taken by plants from the air and built into cellulose, starches, and proteins. Some of the carbon is oxidized directly by cells of the plant and returned to the air. Plants die and are returned to the soil or the plant becomes food for animals. Both within the plant and the animal,

the carbon is built into fats, protein, carbohydrates, or directly oxidized and returned to the air. The waste products are subjected to bacterial action and where the action is complete, carbon is converted into carbondioxide again or into carbohydrates. Bacteria are thus the agents which conserve the carbon supply.

The cellulose of woody tissue of plants is acted upon by many organisms—namely, molds and Streptothrix, which are higher bacteria and look like mycelial threads of mold. The nitrogen absorbing bacteria and denitrifying organisms are also active in cellulose decomposition. Intermediate products of the process are organic acids and under anaerobic conditions, (absence of air) the production of hydrogen and methane. · (CH_4).

Nitrogen is present in organic remains in the form of complex proteins. By a series of reductions, decomposing bacteria reduce these complex proteins to the form of ammonia (NH_3) and finally to free nitrogen. The nitrogen waste in animals and birds, in the form of urea and uric acid especially, is reduced likewise to the form of ammonia (NH_3).

Nitrifying Bacteria.

Within the soil a class of nitrifying bacteria (nitrous and nitric bacteria) convert ammonium salts into nitrates or salts of nitric acid. It is important that a base such as lime be present in the soil, in order to unite with this acid form of nitrogen. These bacteria do not require light to enable them to grow and they can obtain their nitrogen, carbon and other food elements from inorganic salts. Plants, on the other hand, take their carbon from carbon dioxide. Thus these forms of bacteria are absolutely independent forms of life and may have existed before the period of higher green plant life occured upon the surface of the earth.

The work of these bacteria is to convert nitrogen into the form of nitrates, in which state nitrogen is assimilated by plants.

Deintrification is the reverse of nitrification. The latter is an oxidation process by which oxygen is added by the activities of bacteria and organic nitrogen converted into nitrates. Denitrification is, on the other hand, a reduction process whereby the nitrate is made to part with its oxygen wholly or in part and is changed to a nitrate, to ammonia, or to nitrogen gas. The reduction to a nitrate or to ammonia does not remove nitrogen from the soil, as it may again be oxidized to a nitrate. But once reduced to free nitrogen, it is returned to the air and last to the soil and to the crops.

The denitrifying bacteria require a certain amount of oxygen for their growth. When oxygen is absent, they take it out of the nitrate (NO_3). Thus denitrification is favored by an exclusion of

air. This explains the reduction of nitrate in water-logged surface soil and the tendency to denitrification in heavy compact soils as compared with the more open sandy loams.

Drainage, liming, and thorough tillage, greatly lessen the danger from denitrification by improving the circulation of air in the soil.

The Symbiotic Root Tubercle Nitrogen Fixing Bacteria.

Much has been written regarding the relation of legumes to the tubercle forming bacteria that grow upon their roots. But because of their importance to a permanent system of agriculture, it is well to call attention to them in this short review of the soil bacteria.

These root tubercle bacteria (Bacillus radiciola) are parasites. They require carbohydrate material and are unable to manufacture it from the elements of carbon, hydrogen, and oxygen; consequently they derive it by growing upon the roots of leguminous plants. The agricultural plants included under the term legumes are: alfalfa or lucerne; clover; melilotus or sweet clover; peas; beans; and vetches.

The bacteria can enter the roots of legumes when the latter are in a weakened condition, such a state resulting when the nitrogen supply of the soil is deficient. In a weakened state, they have slight power of resistence, and the nodule bacteria, seeking carbohydrate material, gain enterance to the root through the tip of the root hairs. The bacteria may possibly secrete an enzyme which dissolves the substance of the tip of the root. After they have entered the root, the bacteria cause excessive reproduction of the plant tissue about it, which results in the formation of the tubercles. The bacteria are not found in all parts of the plants, but are confined to the nodules and rootlets. The presence of bacteria upon seeds results from the contamination of the seed with soil.

The symbiotic bacteria, developing in the nodules, absorb nitrogen from the air circulating in the porespaces of the soil. The nitrogen absorbed by these bacteria becomes immediately available to the plant. Soil fertility, however, is only increased when these plants become dead and have passed through the cycle of decomposition (humus, ammonia, nitrous salts, nitric salts).

Although past attempts to develop these bacteria to grow upon non leguminous plants have been unsuccessful, it may yet be possible to do so.

Action of Bacteria upon Potash and Other Minerals.

As a result of various bacterial activities, there is a production of carbon dioxide (CO_2) which, on being absorbed by soil water, forms a weak carbonic acid solution; it thus increases the solvent action of water, and in this manner aids in rendering plant food in an available form. Silicates of potash, unavailable to plants, may be decomposed by carbonated water and in the presence of lime the potassium silicate may be converted into potassium carbonate, a form of potash that is available to the plant.

Another action of bacteria in dissolving mineral within the soil is by their production of organic acids in decomposing humus.

The bacteria acting upon iron are not true bacteria, but belong to a higher thread like form. They deposit in the sheaths of their cells quantities of ferrous hydroxide or ferrous oxide. They grow in water charged with iron carbonate and are known to develop to such an extent in water pipes as to clog them with ferrous hydroxide.

When decomposition of animal and vegetable remains goes on under anoerobic conditions, iron occurs as the sulphide when under aerobic conditions, it occurs as ferrous carbonate.

It is doubtful whether these organisms are essential in maintaining a circulation of iron in the soil.

Action of Bacteria in Relation to Sulphur.

Usually sulphates are present in sufficient amounts within the soil. They are taken by plants and converted into protein material. Plants either die and decompose or are eaten by animals. In the former case, as a result of bacterial decomposition of proteids, hydrogen sulphide is produced. A group of sulphur oxidizing bacteria (Beggiatoa), which are thread like, oxidizes the hydrogen sulphide (H_2S) to furnish energy, and store up sulphur in its cells. When the hydrogen sulphide becomes diminished, these bacteria oxidize the sulphur, which then becomes sulphur dioxide (SO_2). They do this without the aid of light or any pigment. Another colorless group of sulphur bacteria is Thiotrix.

Other forms of sulphur bacteria are red pigmented, the red pigment being analogous to the action of chlorophyll in plants. These bacteria require light for growth. They occur abundantly in sea water near the shore. The red color occasioned by the development of bacteria has given the Red Sea its name.

There probably are certain bacteria that act upon phosphorous. In the decomposition of proteid material (of which phosphorous is a component) there are two end products, under anaerobic conditions the end product is phosphein (H_3P); under aerobic conditions the end product is phosphoric acid (P_2O_5).

Generally the practises of modern agriculture are advantageous to the development of bacteria within the soil.

The amount of moisture in the soil and the degree of aeration are controlled by the mechanical operations of plowing, discing, harrowing, and rolling. The resulting condition of moisture and aeration affects the rate of increase of the soil bacteria.

The application of manures and fertilizers and the turning under of green manures produce changes in the soluble salts as well as modifying the conditions of moisture and aeration. Barnyard manure contains bacteria to the extent of one-third of its dry weight. Though a large percentage of bacteria in foeces are dead, the application of several tons of barnyard manure per acre to soils, introduces many millions of bacteria.

Applications of lime affect the rate of development of bacteria by the neutralization of acid conditions and improvement of texture of heavy soils.

The same amounts and proportions of plant nutrients are not taken by different crops. As this causes difference in composition of the soil, there occurs an unequal change in the number and character of the bacteria. A rotation of crops that includes a legume is advantageous to the proper maintenance of an available store of plant food constitutents and the economical use of the soil humus.

Ohio State University.

Plant Life and Plant Uses by John G. Coulter, published by the American Book Company, represents a new type of elementary botany for the high school. It is a very interesting book and its method if intelligently followed will go far to place elementary botany on a firm basis in the high school curriculum. The author has presented a book that corresponds to the capacity of high school children. Too often college professors who have written high school texts have lost sight of the fact that they were addressing immature minds that needed direction and a sympathetic attitude rather than the dry facts and abstractions of a science suitable for the mature college student or graduate. This book followed by a course in elementary agronomy should make an ideal course in what some are now pleased to call "agriculture." If the new "elementary agriculture" now being exploited is to be taught without a basis of knowledge of plants it will accomplish little of value. But even an elementary knowledge of agriculture based on an elementary knowledge of plants should give us a far better practice on the farm, and in the garden than we have had in the past. In city schools the course outlined in the book might well be followed by special courses on trees, gardening and household and food plants in which all city people should have an interest. J. H. S.

MEETING OF THE BIOLOGICAL CLUB.

ORTON HALL, November 3, 1913.

The meeting was called to order by the President, Mr. Stover, The minutes of the previous meeting were read and corrected. The following persons were elected to membership: Lawrence W. Durrell, Gustav A. Meekstroth, Carl J. Drake, Frank H. Lathrop.

In the absence of a report from the nominating committee it was moved and seconded that the nominations for the officers for the ensuing year be made from the floor. Those nominated were: W. J. Kostir, for president, Clara G. Mark for vice-president and Blanche McAvoy for secretary.

The Secretary was instructed to cast a vote for these persons.

Mr. Kostir took the chair and introduced the speaker, Mr. Stover, who gave the presidential address on the Present Aspects Phytopathology.

The meeting adjourned at 9:10.

BLANCHE W. MCAVOY, Secretary.

ORTON HALL, December 8, 1913.

The meeting was called to order promptly at seven-thirty by Mr. Kostir. The meeting was well attended, there being a few more than one hundred present. The minutes of the previous meeting were read and approved.

Benj. H. Repp, Dan G. Tear, and Mary Blanche Howe were elected to membership.

Prof, Griggs had the first paper of the evening. It was a record of his trip to Alaska and was entitled "The eruption of Katmi, an Alaskan Volcano, and its Effect on the Vegetation." Katmi is on the peninsula and erupped on June 6, 1912. So far as is known there were no warning eruptions. The noise was heard 750 miles and the steam from the volcano was seen for 100 miles. At Kodiac which is 100 miles away the ashes fell to the depth of one foot and the darkness lasted for sixty hours. There was approximately 4.9 cubic miles of material thrown up. Great quantities of pumice were floating on the water. Soon after the eruption it rained and the lava became mud which washed down off the mountains and hills and filled up the valleys and covered the houses. To illustrate the effect of all this on the vegetation he showed pictures of places, that he had taken similar to the region around Katmi. The pictures showed great meadows and forests and quantities of flowers. The pictures taken around

Katmi showed devastation every where. The eruption occured just after the leaves on the trees had opened. As the result the growth for 1912 and the leaf buds that would have opened in 1913 were killed so the trees looked dead altho the wood was not injured and probably in another year many of the trees will put out leaves and go on growing. Equisetum seemed to be the plant that came up first thru the lava. The Indians thought that it had been thrown up by the volcano.

Prof. Barrows showed a number of guinea pigs. The agoute type is black haired, tipped with red. If the agoute is absent black results. He has had trouble in getting pure black. Among others he showed a silver agoute. If the chocolate is absent in the color coat red results and if red is absent yellow results. If yellow is modified cream results. He had a tricolor in which the inheritance is hard to work out. The other color coats are strictly Mendelian but the spots are seemingly not.

Mr. Meekstroth reviewed two papers on plant variation from the New York Botanical Garden. One was on the leaf variation in hybrid violets and the other a bud variation of the white margined Pelargonium. He had a number of slides to illustrate his review. The cross in the violets was made between the bird-foot and several entire leafed species. The result was intermediate.

Observations were made of a wheel bug sent to Prof. Osborn and new for the state. The report of wild pigeons found in Michigan was spoken of and criticized. Prof. Alfred R. Wallace's death was noted. A Zamia that is in bloom in the green house was mentioned. L. W. Durrell told of his new stippeling machine and said that he would demonstrate it after the meeting.

The meeting was then adjourned.

Blanche McAvoy, Secretary.

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A PRELIMINARY REPORT ON RASPBERRY CURL OR YELLOWS *

LEO E. MELCHERS

Raspberry curl, or "yellows," can probably be regarded as the most serious of raspberry diseases. This malady was first reported by Green in Minnesota (1894), and is apparently the same trouble as mentioned by Stewart and Eustace (1902), who called it "raspberry yellows." The writer believes that the original name, raspberry leaf curl, or raspberry curl, is descriptively more appropriate and lessens the possibilities of a misconception regarding its undetermined cause.

Although this malady has been known for some years, little work seems to have been done upon it. Green (1895), reported raspberry leaf curl as the worst raspberry disease in the state. Stewart and Eustace (1902), reported raspberry yellows as occurring in New York; they regarded it as distinct from raspberry cane blight caused by *Coniothyrium fuckelii* Sacc., (*Leptosphaeria coniothyrium* (Fckl.) Sacc., and the description of its field characteristics show it to be entirely different. Clinton (1903, p. 35), mentioned cane blight of raspberries, but from the symptoms given, namely, that "the foliage of the infected cane is usually streaked with yellow and crinkled," he appears to have been describing the raspberry curl disease, for the above symptoms are not characteristic of cane blight caused by *Leptosphaeria coniothyrium* (Fckl.) Sacc. Paddock (1914-5), stated that raspberry yellows attacked the Malboro in Colorado. Sackett (1910), merely mentions raspberry yellows, without giving any descrip-

* Department of Plant Pathology, Kansas State Agricultural College, Manhattan, Kansas.

tion of its symptoms. In a later report (1911, p. 18), he speaks of spraying experiments in connection with "Project III Raspberry Yellows."

He does not clearly distinguish between raspberry "yellows" and raspberry cane blight. Interpretation of his results indicates that spraying with Bordeaux mixture controlled both diseases—a conclusion which is not in accord with the writer's experience with raspberry curl.

Fig. 1. Plants affected with raspberry curl showing the stunted growth and bushy appearance.

Lawrence (1911), assigns various factors as a possible cause of raspberry yellows, among them fungi, poor grainage, lack of soil fertility etc. A "bacterial disease" of raspberries was reported by Detmers (1891) in Ohio. From the description of the disease, the malady is undoubtedly the one under discussion.

The name "raspberry yellows" has been and is used indiscriminately to cover a multitude of symptoms. In some instances in which people have heard that there is such a disease as "raspberry yellows," a case definitely diagnosed as such, because a few yellow leaves happen to be present. The true raspberry curl, or "yellows", has very definite, striking, characteristic symptoms and should not be confused with unthriftiness of plants due to cultural conditions nor to a drying or blighting of the leaves and canes as brought about by raspberry cane blight.

Occurrence of Raspberry Curl. Raspberry curl is found mainly on Cuthbert, Marlboro, Golden Queen, Early King and Herbert, the varieties being susceptible in the order named. Cuthbert and Marlboro are probably the most susceptible varieties, and at present are being discarded entirely for commercial purposes. The disease is found occasionally in other varieties of red raspberries, but very rarely on black caps or purple kinds.

Besides occurring in Minnesota and New York, it has been reported in Connecticut and Colorado. The writer has found this disease in Ohio, Michigan, California, and Washington, and it is probable that this same trouble occurs in Canada, Massachusetts, Pennsylvania, and Kansas, while not improbable that it could be found in most localities where the red raspberry is grown extensively.

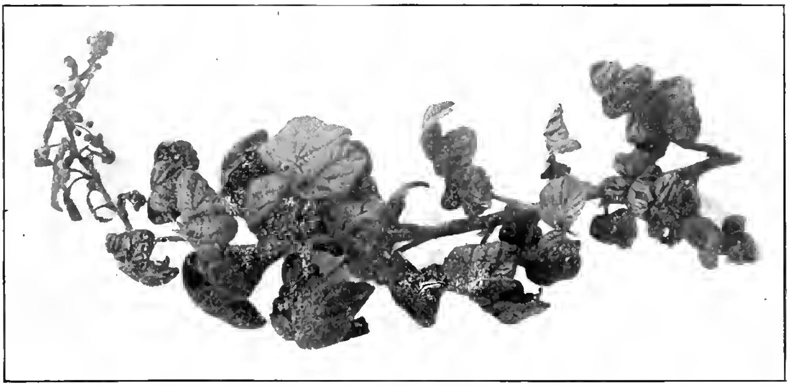

Fig 2. Current year's growth showing premature flowering.

Economic Importance. The writer has made a study of raspberry curl in Ohio, especially in Lucas and Cuyahoga counties, two localities which have grown raspberries extensively. In these regions red raspberries were at one time a very important crop. Today there is grown only one-fifth the acreage of eight years ago. This falling off has been due, as far as can be ascertained, entirely to the raspberry curl disease. A number of growers conservatively estimate an annual loss of $200 per acre due to this disease.

Symptoms of Raspberry Curl. Generally the disease does not make its appearance until the second year after planting, while sometimes three season elapse before it becomes severe enough to attract attention. When it once appears in a plant, it invariably reappears annually to a greater or less extent and as long as

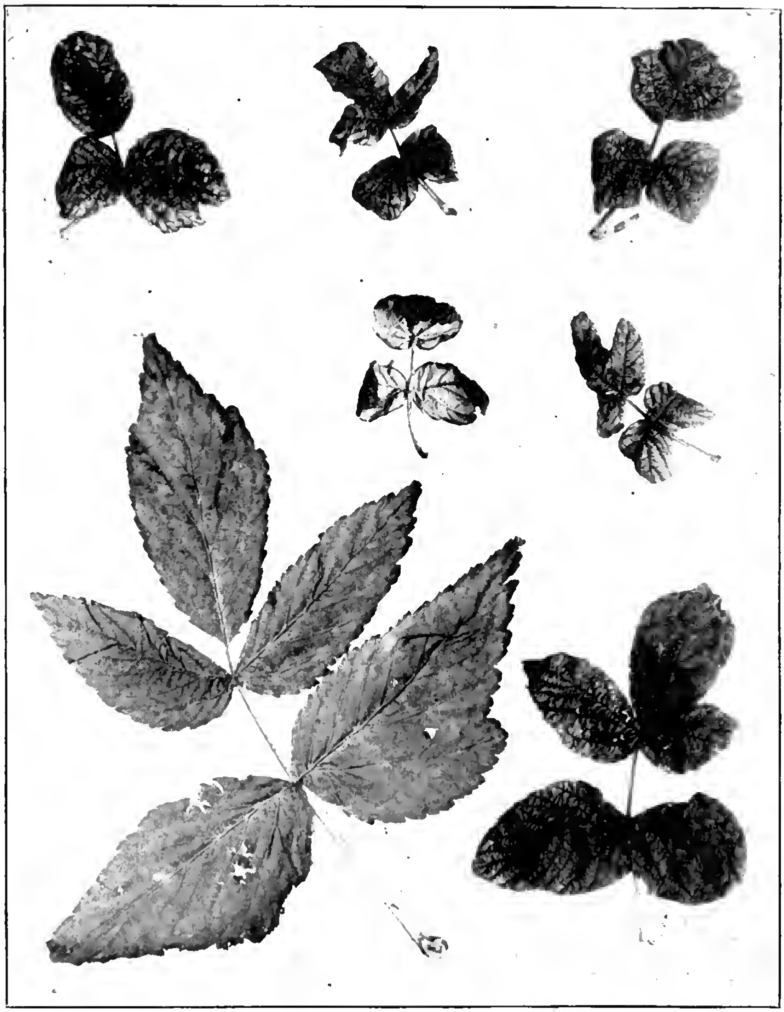

Fig. 3. Showing comparative size of healthy and diseased leaves, also the sunken vascular system and the arching uwpard of the intervenal tissues.

that plant happens to live. According to some of the older growers in Lucas county, raspberry plants twelve years old are said to have produced this "curly foliage" annually for nine years.

One of the more striking symptoms of this disease is the stunted or dwarfed appearance of the plant. See fig. 1, compare with fig. 5. A withering or blighting of the canes or leaves never occurs in the case of this disease. There are no indications of a lack of turgescence in any of the tissues of an affected plant.

The canes are short, and when the fruiting laterals are formed the plant has a compact, bushy appearance. The internodes both in the canes and in the laterals are very short. We may have

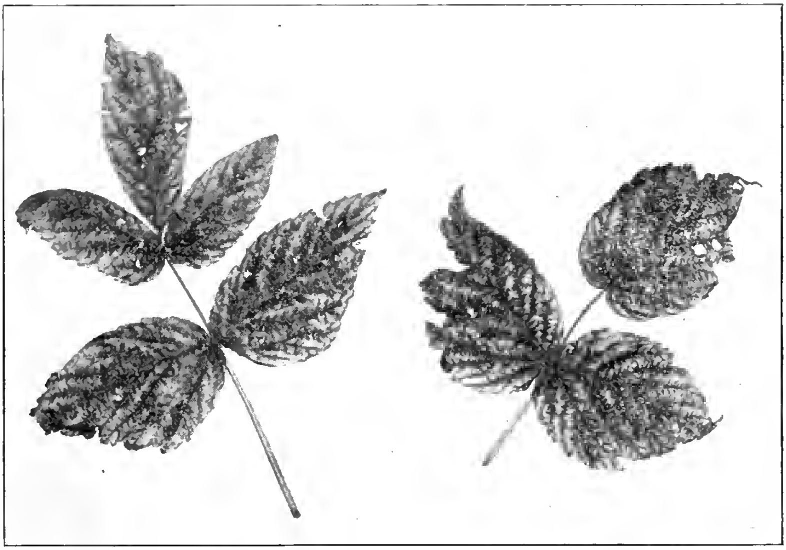

Fig. 4. Mottled effect of the leaves of raspberry curl.

apparently healthy and diseased canes arising from the same crown. Premature flowering of the current years' growth is not uncommon, terminal inflorescence being frequently present, as shown in fig. 2. Diseased sprouts emerge from the soil with a sickly, pale yellowish-green color, the leaflets being small and more or less curled. The writer has observed such sprouts arising at a distance of *three feet* from the parent crown. As these canes grow older, the leaflets become darker green and noticeably revolutely curled. See fig. 3.

The most striking characteristic of the diseased leaflet blade, is the arching upward of the intervenal tissues, which cause the vascular system to appear sunken. See fig. 3. It is this

uneven expansion of tissues which brings about the revolutely curled condition of the diseased foliage. During the summer months the foliage may acquire a mottled appearance, at first a light yellow, gradually changing to darker shades of green and yellow and eventually transforming into a reddish-bronze hue. See fig. 4. The severity of curl and variations and intensities of color depend very greatly upon soil and climatic conditions. An abundance of rain is unfavorable to the development of the above symptoms, while hot and dry weather produce the more conspicuous cases. All diseased foliage, besides being curled and mottled, is considerably smaller and never attains its natural size. See fig. 3. In September or October it is not uncommon to find

Fig. 5. Two-year-old healthy Cuthbert raspberry plants.

considerable mottled foliage; the spots may vary from a yellowish tinge to a bronze, in many cases not unlike mosaic disease in their color, size, shape and location with reference to the vascular system. See fig. 4.

The berries mature from ten days to two weeks earlier than the normal crop. They are small, often deformed, lighter in color than the normal berry, and when apparently ripe are bitter, later becoming insipid. If allowed to remain on the cane until they become "dead ripe", they acquire a slight flavor, which is, however, far from pleasant. In fact the berries are so small and poor in quality that berry pickers refuse to pick at the customary price per quart and commission men will not handle the fruit on account of its inferior qualities.

From general appearanees, the root system of diseased plants seems normal. This disease is peeuliar in that we may have diseased and healthy plants of the same or different varieties growing side by side. This has often been observed by the writer where Cuthbert and Early King were growing in the same row, the former variety always being the more suseeptible. It is also of interest to note that raspberry eurl may make its appearanee in a plot even though eane blight has never been known to oeeur among sueh plants. The writer has likewise notieed that although eane blight may be very severe in a pateh of berries, a careful seareh did not reveal the presenee of a single ease of raspberry eurl.

Cause of Raspberry Curl. As yet no definite eause ean be assigned to this disease. Stewart and Eustaee (1902), intimated that it might be related to the so-ealled physiologieal diseases, sueh as, peaeh yellows, while others are attaeking this problem with the expeetation of loeating a pathogen. Paddoek (1904-5), notieed that the disease was more pronouneed where plants were growing in a soil whieh had a high water table. This in part agrees with the observations made by the writer, partieularly where plants were growing in a heavy soil. It was thought at one time that inseets might be eontributing faetors toward the produetion of these eurled leaves. The opinions of entomologists whieh the writer has at hand, however, do not substantiate this.

The writer has made numerous attempts at isolating a eausal organism, seleeting different parts of diseased tissue of various ages, but up to the present time no organism has been obtained whieh has been eonelusively shown to be the eause of this disease. Old erowns frequently eontain various fungi, but their eonneetion with the appearanee and produetion of raspberry eurl, in the writer's opinion, is problematieal. An attempt was made to eorrelate this disease with the oeeurenee of crown gall on raspberry plants, but of the hundreds of plants examined, no relationship was found to exist.

At present the writer is making a histologieal study of diseased tissues. So far, he has been unable to loeate baeteria or fungi in typieal speeimens whieh have been examined. This, however, is not to be interpreted as meaning that a pathogen does not exist in the diseased tissues of the raspberry plant. Inability to discover an organism up to this time may be due to various faetors, sueh as the size of the organism eoneerned or the diffieulty in properly staining and differentiating the very fine myeelia within the host tissue. Further studies are being made along this line, and a more detailed report will be published later.

The writer has had oeeasion to observe that heavy, eompact soils, laeking proper drainage, are more liable to have plants affeeted with raspberry eurl, than lighter soils whieh are ade-

quately drained and aerated. During rainy seasons we apparently have less of this disease than during hot and dry weather. Indications are that the soil fertility question is not directly involved.

Recommendations. In planting red raspberries, secure plants from localities where raspberry curl does not occur. Grow varieties which do best in your locality and which seem adapted to your soil conditions. St. Regis seems to be a promising variety not so susceptible to this disease. Early King and Herbert are standard varieties doing well in some localities. The former is is the only red variety which can be economically grown in Lucas county, Ohio, and is entirely replacing all other varieties.

Plant on a rather light or medium heavy soil which is provided with adequate drainage. The addition of barnyard manure well incorporated into the soil is of value in producing vigorous and thrifty plants. Where irrigation is possible, it is highly beneficial and is advisable, especially during adverse seasons.

Plants affected with raspberry curl are best removed and destroyed, as they are worthless for the production of marketable fruit. Never use disease plants for propagation purposes.

The application of fungicides is useless in controlling raspberry curl.

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SOME UNREPORTED CECIDIA FROM CONNECTICUT

B. W. Wells

Thru the winter of 1912-1913 and the summer of 1913, in preparing for some work on abnormally developed plant parts, the writer made a collection of insect galls in the eastern highland region of Connecticut. Most of the field work was done in the town of Mansfield in the vicinity of Storrs and Spring Hill. The extreme northern part of the eastern half of the state was visited a few times as well as the southern portion bordering on Long Island Sound. In the course of eleven months residence in the eastern Connecticut region, 204 galls were found, 22 of which are believed to be as yet unreported in the United States.

The object of the present paper is thus to present descriptions and illustrations of some heretofore undescribed cecidia produced by insects and mites in the eastern Connecticut highland region. A bibliography of the more important literature consulted, is appended.

The writer wishes to express his appreciation of valuable assistance rendered by Mr. Billings T. Avery of Ledyard, Conn. who not only materially assisted in enlarging the collection of previously described galls but found a number of the new ones described in the present paper.

It is self evident that such a report as the present one in which the galls only are adequately described, is an imperfect report. Yet, a list of these newly discovered definite hypertrophies and hyperplasies of plant parts should be set forth as a basis for future work, in which the whole of the subject entomological as well as botanical may be elucidated. Such a paper as the present one may perhaps act as a stimulus to the collection of cecidia by showing the unworked condition of the field. The animal induced pathologic structures developed on plant parts have not been collected with any degree of completeness; and no full and extended systematic studies have been made of those collected in America. Careful search in any locality, particularly among herbaceous plants is bound to bring to light some little known or entirely new cecidia.

The writer has left the matter of naming the causal organisms to future workers, believing that specific names should be originated by the first describer of the mite or insect concerned. The custom on the part of some of applying a specific name to an insect or mite merely on the basis of the intimately associated gall, is to be deplored. New names of gall producing forms should appear only with adequate descriptions of the arthropods concerned.

The galls herein described and believed to be heretofore unreported, are arranged on the basis of the plant affected. The plant genera are arranged alphabetically, Gray's Manual being followed in the matter of nomenclature.

Acer saccharum. Leaf Gall. Gall maker, not found.

A small, monothalamous, laterally flattened gall on the underside of the leaf veins. 3-4 mm. dia. Semicircular in outline as seen from the side. The vascular tissue traverses the edge of the gall. Gall opens above by a slit which is bounded by definite lips. No pubescence present. Green in summer, brown in dried condition. Fig. 1.

Amelanchier canadensis. Leaf Gall. Gall maker, not found.

A small, monothalamous, smooth, cone-shaped gall, prominently curved at the tip, occurring on either side of the leaf. On the side opposite the gall is a short narrow slit, definitely lip-bordered, which leads into the small chamber. In mid-summer the galls are yellowish at the base to red or brown black at the tip. Under lens the surface is finely striate. No pubescence. When found they occur in great numbers on the leaves of the shad-bush, where they are distributed heterogeneously; bearing no relation to the venation system. Common locally. Fig. 2.

Possibly the gall described by Hagen (33) and Chadwick (22) as "similar to a Phrygian cap, the tip rolled down; on the upper side of the leaf, rarely below."

Amelanchier canadensis. Leaf Gall. Gall maker, unknown.

A flattened, monothalamous, pocket gall occurring in numbers on the underside of the leaf. 3-4 mm. long. Distal edge toothed, rarely more than three pointed. Ivory white, smooth as tho polished. Cavity confined to the proximal two thirds of the gall. Wall smooth. Opens on the opposite or upper side of the leaf by a narrow slit sunken in a depression of the blade. Galls are locally abundant.

Undoubtedly an insect gall, whose larvæ leave the cecidia by mid-summer. The material described was collected in Aug. and showed no inhabitants of any kind. Fig. 3.

Possibly the same as Felt's (29) "flattened, white, pouch gall on leaf margin, denticulate. Cecidomyia sp." The galls, however, are scattered over the leaf blade.

Betula lenta. Leaf Gall. Gall maker, undetermined.

A monothalamous, closed vein gall on the principal veins of the leaf. 5-10 mm. long, often merging into each other. Narrow, not over 1/2 mm. wide. Smooth and color of the normal vein. Tubular cavity small. Larvæ not found. Not common. Fig. 4.

Carya ovata. Leaf Gall.

A bright red, sub-globular, monothalamous, fleshy gall on the under side of the leaflet. At first white, later red (July 16) 3 mm. high, 5 mm. broad. A slight papilla terminates the apex. Wall of larval chamber white, rest of tissue reddened. Larva white. Fig. 5.

Castanea dentata. Leaf Gall. Gall maker, an undetermined aphid.

A marked wrinkling and crumpling of the leaf particularly in the region of the mid-vein. No definite cavities formed. Aphids numerous, scattered in the folds of the distorted intervenal tissue. Not common. Fig. 6.

Castanea dentata. Leaf Gall. Gall maker, Eriophyes sp.

This gall consists of a yellowish erineum developed between the secondary veins of the leaf, chiefly on the upper side. Exhibits a shallow concavity above.

Clematis virginiana. Bud gall. Gall maker, Eriophyes sp.

A gall of the terminal leaf bud made up of the greatly hypertrophied and rigid leaf petioles. These assume the form of irregular flattened scales. On each of the outermost ones the three minutes leaflets can be readily seen borne on the summit of the highly expanded petiole. The sub-spherical galled bud measures about 1 cm. in dia. The irregular cavities within are nearly filled by the dense growth of filamentous trichomes. This white pubescence chokes up the entrance way between the outermost scales.

This gall often develops irregularly and the enlarged semi-woody petioles are so compactly pressed together, that its essential morphology might be missed in a hasty examination. Fig. 7.

Evidently the same gall as one produced on C. Flammula and described by Frank, A. B. (30).

Decodon verticillatus. Bud Gall. Gall maker, a cecidomyid insect.

A gall formed by the thickening of the two or three uppermost minute bud leaves of the terminal or lateral buds. Galled bud 3-5 mm. long. Green. The two or three modified leaves neatly overlap forming a well protected chamber within, which contains a single salmon colored larva. Rather common. Fig. 8.

Dulichium arundinaceum. Stem Gall. (Rachilla.) Gall maker, a cecidomyid insect.

A monothalamous, open, "groove" gall of the rachilla. One or generally two internodes involved. The normal rachilla is grooved both sides and the gall chamber is an enlargement of the deeper one whose edges are the membranaceous, decurrent bract base. The galled rachilla is so prominently hypertrophied that the affected spikelets can be picked out at a glance due to their greater width.

Larvæ bright salmon color, breast plate prominent. Evidently mature Sept. 1. Galls common on Dulichium in the Conn. region. Figs. 9, 10 and 10a.

Hamamelis virginiana. Leaf Gall. Gall maker, unknown.

A monothalamous, "groove" vein gall opening on the upper side of the leaf. Affecting principal veins. Variable in length, 1-3 cm. long. Surface minutely roughened, green, turning black when old. Not common. Possibly the same as Felt's (29) "fleshy vein folds. Cecidomyia sp." Fig. 11.

Juncus canadensis. Bud and Stem Gall. Gall maker, not determined.

Elongated bud-like galls made up of overlapping leaves. The branch axes are very much shortened causing the leaves to tightly enfold one another. From four to seven of these affected branches or galls occur together in a cluster. Average length of gall, 4 cm. Green. Fig. 12.

A gall exactly similar to this is pictured by Connold (23) who states that the gall is formed by the larva of Livia juncorum, Latr. Reported from Hastings, England. Fig. 12.

Mikania scandens. Stem Gall. Gall maker, undertermined.

A large, monothalamous, fusiform gall of the stem internode. 1-2½ cm. long, ½ as wide. Six longitudinal low ridges divide the surface area into as many faces. Surface smooth, color of the normal stem. Texture tough almost woody. Cavity large (as wide as the wall is thick) extending the length of the gall. A single white larva found within. Fig 13.

Muhlenbergia mexicana. Bud Gall. Gall maker, undetermined.

A lateral bud gall formed by an extreme shortening of the axis resulting in a compact structure made up of overlapping leaves. The leaves, tho greatly reduced in length and much broadened still show the sheath and blade portions definitely divided by the minute ligule. 4 cm. long, 1 cm. wide.

The larvæ (Aug. 20th) just visible distributed in the spaces at the very base of the sheaths. Fig. 14.

Myrica asplenifolium. Leaf Gall. Gall maker, Eriophyes sp.

A gall formed by the thickening and folding of the mid-vein. with which it associated an incurling of the leaf edges. If the entire mid-vein is affected, the whole blade is much contorted. Reddish and smooth without. A thick, white pubescence fills the cavity within. The trichomes are highly elongated. Not common. Fig. 15.

Ostrya virginiana. Leaf Gall. Gall maker, Eriophyes sp.

A small, sub-spherical pocket gall generally on the upper side of the leaf. 1-2 mm. dia. Red tinged, smooth. Opening below marked by a tuft of white hairs. Few or many on leaf. Not common. Fig. 16.

Rhus copallina. Leaf Gall. Gall maker, Eriophyes sp.

A terminal mass of dwarfed branches, bearing abortive leaves, the leaflet margins of which are strongly inrolled. In addition the leaflets are more or less contorted. No definite crineum present.

A gall identical to this has been collected on R. glabra.

Fig. 17 illustrates merely one of the numerous dwarf branches. Fig. 17.

Jarvis, 39th Ann. Rept. Ent. Soc. of Ont. 1908. p. 90 (35) a similar gall on Rhus typhina.

Salix sericea. Leaf Gall. Gall maker, undetermined.

A monothalamous, elongate, irregular, tubular gall formed in the blade of the leaf near to and paralleling the margin. The edge of the leaf is turned, simulating the nest of a leaf roller insect. There is, however, a marked hyperplasia of tissue. 1-1½ cm. long. Smooth, light green above. Thin walled. The escapement pore is below at the distal end. No larvæ or pupæ present Sept. 1. Fig. 18.

A similar gall is found in England on Salix viminalis caused by Cecidomyia marginem-torquens, Wtz. See Connold, (23) British Vegetable Galls, p. 194. 1902.

Solidago odora. Terminal Bud Gall. Gall maker, undetermined.

A monothalamous gall probably formed by the transformation of the growing point of the terminal bud into an olive shaped structure, 15 mm. long, 11 mm. wide. Base enveloped by an involucre like mass of overlapping leaves. Surface reticulately marked. Areas brownish. The distal region surrounding the mucronate tip, green and smooth. The single elongate flash-shaped cavity contains one large white larva. In long. section the walls are observed to be composed of a compact pith, thru which more or less prominent vascular bundles are distributed. Not common. Fig. 19. A longitudinal median section is shown in Fig. 19, a.

Spirea latifolia. Bud Gall. Gall maker, a cecidomyid insect.

Galled terminal and lateral buds. The leaf primordia develope into thick green scales, which overlapping form the large larval chamber within. 7-10 mm. in length. Many larvæ (possibly inquilines) to a gall chamber. Possibly one of the following: Fig. 20.

Jarvis, "A bud-like sessile gall in the axil of the leaf." "Undescribed)" 39th Ann. Rept. of the Ent. Soc. of Ont. 1908. p. 90.

Felt, (29) reports a "terminal globular bud gall, 4 mm. Hormomyia clarkei, Felt."

Tilia americana. Leaf Gall. Gall maker, undetermined.

A monothalamous, fusiform hypertrophy at the base of the petiole, 10 mm. long, 5 mm. wide. Surface and color same as the normal petiole base. Texture tough, almost woody. Chamber, elongate, narrow, flattened lying centrally. A single white larva present. Fig. 21.

Vitis aestivalis. Leaf Gall. Gall maker, an undetermined insect.

A small, monothalamous, sub-cylindric gall, extending both sides of the leaf. Hairy on both sides with reddish brown hairs below, lighter above. 2-3 mm. Walls rather thick. Pupa present July. Not common. Fig 22. Plate II.

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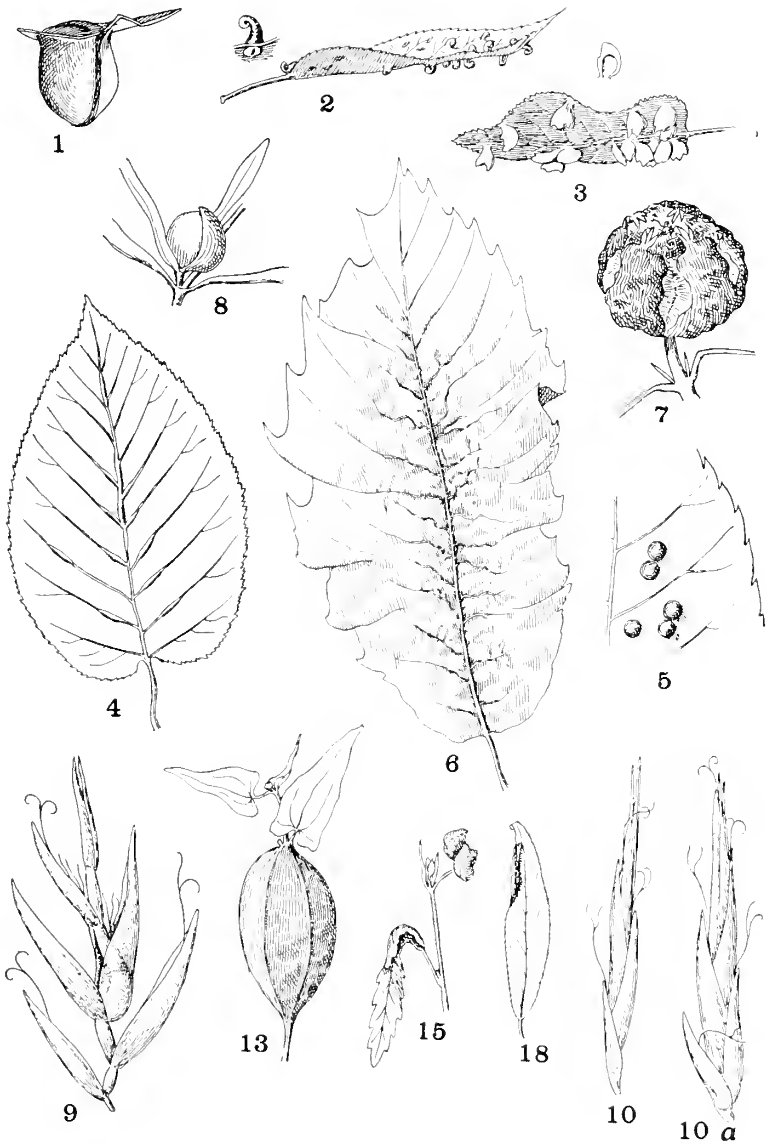
EXPLANATION OF PLATES.

PLATE XII.

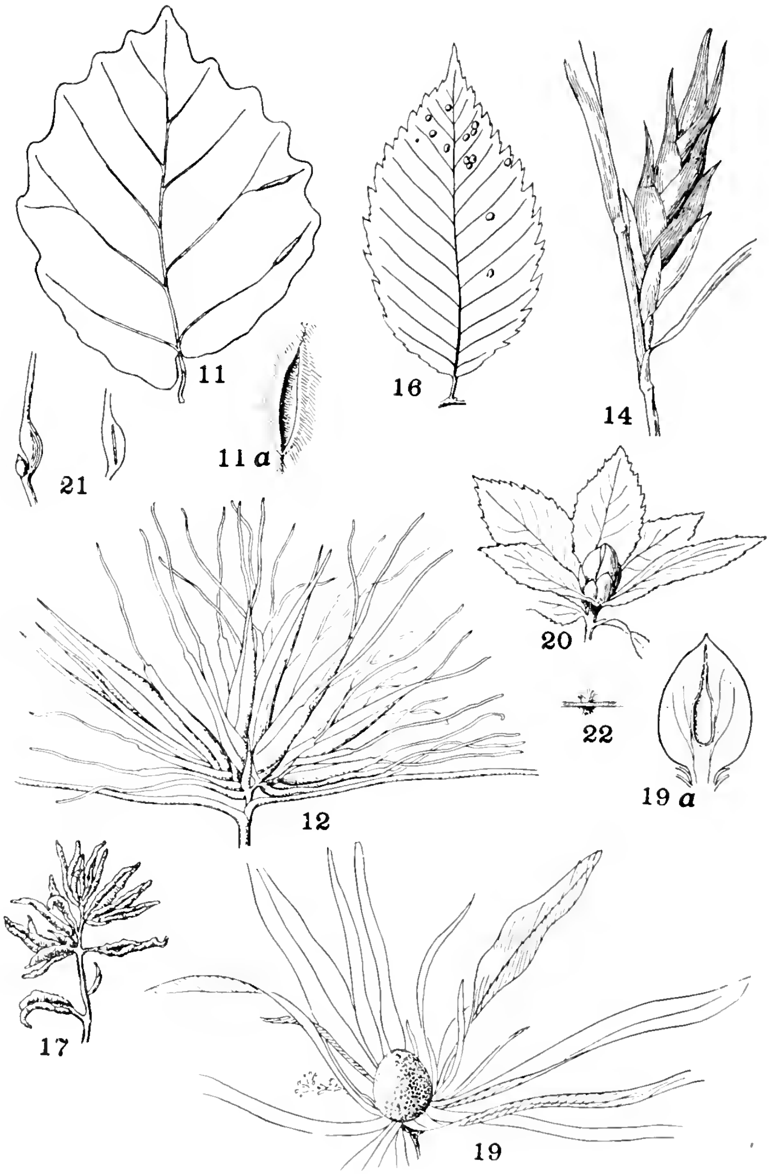
Fig. 1. Acer saccharum. Vein gall. x4.
Fig. 2. Amelanchier canadensis. Leaf with galls. x1. Single gall. x5.
Fig. 3. Amelcanchier canadensis. Leaf with galls. x1. Single gall in section slightly enlarged.
Fig. 4. Betula lenta. Vein gall. x¾.
Fig. 5. Carya ovata. Leaf gall. x¾.
Fig. 6. Castanea dentata. Aphid leaf gall. x¼.
Fig. 7. Clematis virginiana. Bud gall. x1.
Fig. 8. Decodon verticillatus. Bud gall. x1.
Fig. 9. Dulichium arundinaceum. Opened spikelet showing galled rachilla.
Fig. 10. Dulichium arundinaceum. Normal spikelet.
Fig. 10a. Dulichium arundinaceum. Galled spikelet. See Fig. 9.
Fig. 13. Mikania scandens. Stem gall. x1.
Fig. 15. Myrica asplenifolium. Mite leaf gall. x½.
Fig. 18. Salix sericea. Leaf gall. x½.

PLATE XIII.

Fig. 11. Hamamelis virginiana. Leaf with vein galls. x¼.
Fig. 11a. Hamamelis virginiana Vein gall from upper side. x¾.
Fig. 12. Juncus canadensis. Bud and stem galls. x½.
Fig. 14. Muhlenbergia mexicana. Bud and stem gall. x½.
Fig. 16. Ostrya virginiana. Leaf with galls. x⅓.
Fig. 17. Rhus copallina. Galled leaflets. x1.
Fig. 19. Solidago odora. Terminal bud gall. x¼.
Fig. 19a. Solidago odora. Long. med. section of 19. x½.
Fig. 20. Spirea latifolia. Bud gall. x⅔.
Fig. 21. Tilia americana. Petiole gall. x⅔.
Fig. 22. Vitis aestivalis. Leaf gall. x1.



Wells on "Cecidia."



Wells on "Cecidia."

THE HONEYSUCKLE FAMILY IN OHIO.

LILLIAN E. HUMPHREY.

CAPRIFOLIACEAE. Honeysuckle Family.

Shrubs, trees, or perennial herbs with opposite leaves, with or without stipules; flowers axillary or terminal, sympetalous, usually pentamerous except the gynecium, epigynous, actinomorphic or zygomorphic, often 2-lipped, stamens united with the corolla, alternating with its lobes; ovulary 1-6-locular; styles slender, ovules anatropous; fruit a berry, drupe ,or capsule; seeds oblong, globose, or angular; embryo rather small situated near the hilum; endosperm fleshy.

Synopsis.

I. Style deeply 5-2-lobed; corolla rotate.
  1. Ovulary 5-3-locular; drupe 5-3-seeded; leaves pinnate. *Sambucus.*
  2. Ovulary 3-1-locular; drupe 1-seeded; leaves simple. *Viburnum.*

II. Style single, slender; corolla more or less tubular.
  1. Stigma 5-3-lobed; ovulary 5-3-locular, ovules one in each cavity. *Triosteum.*
  2. Stigma capitate or nearly so; ovulary 3-2-locular, ovules several to many in each cavity, or at least several in some cavities.
    a. Fruit a berry.
      (a). Ovulary with four cavities; corolla campanulate. *Symphoricarpos.*
      (b). Ovulary with 3-2 cavities; corolla short or long tubular.
        (1). Stamens 5; fruit fleshy. *Lonicera.*
        (2). Stamens 4; fruit dry. *Linnæa.*
    b. Fruit a capsule. *Diervilla.*

Key to the Genera.

1. Leaves simple. 2.
1. Leaves compound, pinnate. *Sambucus.*
2. Woody shrubs or vines. 3.
2. Herbs with sessile axillary flowers; leaves connate or sessile, glandular, pubescent, perennial. *Triosteum.*
2. Trailing somewhat woody plants with evergreen leaves; flowers on long peduncles, geminate; fruit tri-locular but one-seeded. *Linnæa.*
3. Flowers with rotate corolla; inflorescence cymose. *Viburnum.*
3. Flowers with tubular to campanulate corollas; inflorescence a terminal spike or in axillary clusters. 4.
4. Leaves entire or nearly so. 5.
4. Leaves serrate, long-acuminate; ovulary elongated; stems ridged laterally; corolla funnelformed, calyx tube long, slender. *Diervilla.*
5. Corolla almost actinomorphic, short, more or less campanulate; leaves normally entire; fruit a 4-locular 2-seeded berry. *Symphoricarpos.*
5. Corolla zygomorphic, 2-lipped, tubular; fruit a several seeded berry *Lonicera.*

Sambucus L. Elderberry.

Shrubs or small trees with opposite pinnate leaves often with stipules and stiples; leaflets serrate, acuminate; flowers white or pinkish-white, actinomorphic, bisporangiate; trimerous to pentamerous, corolla rotate or campanulate; calyx tube ovoid or turbinate; stamens five united with the base of the corolla, filaments slender, anthers long; inflorescence a compound or depressed cyme; ovulary tri-locular to quinque-locular; ovules one in each cavity, pendulous; fruit a berry-like drupe containing 3 to 5 one-seeded nutlets; embryo long.

Key to the Species.

1. Leaflets glabrous above, sometimes pubescent beneath, 5 to 11, ovate or oval; pith large, white; cyme convex. *S. canadensis.*
1. Leaflets and twigs commonly pubescent, 5 to 7; pith in the young branches a reddish brown; inflorescence a compact pannieulate cyme. *S. racemosa.*

1. **Sambucus canadensis** L. Common Elderberry. A shrub 2 to 13 feet high; stem often but slightly woody, containing a large soft white pith when young; leaflets 5 to 11; ovate to obovate, acuminate or acute, short petioled, glabrous above more or less pubescent along the mid-rib beneath, 2 to 5 inches long, $\frac{3}{4}$ to 2 inches broad, serrate; cymes broad, flat convex; flowers white $\frac{1}{8}$ to $\frac{1}{4}$ inches broad; drupe $\frac{1}{4}$ inch in diameter, purplish black; nutlets roughened. In moist soil. General.

2. **Sambucus racemosa** L. Red Elderberry. A shrub 2 to 13 feet high; twigs and leaves more or less pubescent; stems woody with a reddish brown pith; leaflets 5 to 7; ovate to oblanceolate, acuminate, inequalateral, $1\frac{1}{4}$ to 5 inches long, $\frac{1}{2}$ to $1\frac{1}{2}$ inches broad, sharply serrate; cymes elongated, flowers white turning brown; drupe red, $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter; nutlets slightly roughened. In rocky places. General.

Viburnum L.

Shrub or trees with entire or lobed simple, sometimes stipulate leaves; flowers white or sometimes slightly pink, actinomorphic; corolla rotate or campanulate; calyx tube ovoid or turbinate; stamens five, anthers long exserted; inflorescence a compound cyme; outer flowers sometimes radiant and sterile; ovulary 1-3 -locular; style short; three cleft; fruit an ovoid drupe, sometimes flattened, one seeded; seed compressed; embryo minute.

Key to the Species.

1. Leaves palmately veined, 3-lobed, the two lateral veins prominent. 2.
1. Leaves pinnately veined, not 3-lobed, lateral veins 5-11. 3.
2. Leaves glabrous above, pubescent along the veins beneath; outer flowers of the cyme enlarged and flat. *V. opulus.*
2. Leaves more or less pubescent on both sides; cymes not radiant. *V. acerifolium.*

3. Outer flowers of the cyme large and flat. *V. alnifolium.*
3. Outer flowers not enlarged. 4.
4. Leaves coarsely dentate. 5.
4. Leaves serrate or denticulate. 7.
5. Leaves sessile or the petioles not exceeding 1/4 inch; oval to ovate, acuminate, pubescent; stipules long, slender, prominent. *V. pubescens.*
5. Leaves with petioles 1/4 to 1 1/2 inches long, broadly oval, obtuse to long acute. 6.
6. Leaves pubescent beneath, more or less stellate; cyme pubescent. *V. scabrellum.*
6. Leaves glabrous beneath sometimes with tufts of hair in the axils; cyme glabrous or nearly so. *V. dentatum.*
7. Leaves very pubescent, denticulate, cyme stalked. *V. lantana.*
7. Leaves glabrous or nearly so, serrate or crenulate. 8.
8. Leaves ovate-lanceolate, usually crenulate; petioles rather stout; peduncles about the length of the cyme or shorter. *V. cassinoides.*
8. Leaves ovate or broadly oval, margin serrate; petioles slender; cyme sessile or nearly so. 9.
9. Leaves long-acuminate; petioles often wavy margined. *V. lentago.*
9. Leaves obtuse or sometimes acute, oval; petioles rarely margined. *V. prunifolium.*

1. **Viburnum pubescens** (Ait) Prush. Downy Arrow-wood. A shrub 18 to 46 feet high with straight gray branches; leaves ovate or obovate, acute or acuminate, rounded or somewhat cordate at the base, sessile or short petioled, margin dentate, upper surface sparsely pubescent, under surface velvety pubescent, $1\frac{1}{2}$ to $2\frac{3}{4}$ inches long, $\frac{3}{8}$ to $1\frac{1}{2}$ inches broad; cyme peduncled, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches broad, all flowers bisporangiate; fruit an oval drupe about $2\frac{1}{2}$ inches long; stone somewhat 2-grooved on both sides. In rocky woods. Lorain, Erie, Wyandot, Auglaize, Williams.

2. **Viburnum dentatum** L. Toothed Arrow-wood. A shrub about 15 feet high with glabrous branches; leaves $1\frac{1}{2}$ to $4\frac{1}{4}$ inches long, 1 to 3 inches wide, ovate to broad ovate or orbicular, base rounded or somewhat cordate, acute or short acuminate, petioles $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, veins prominent, margin coarsely dentate, both surfaces glabrous except a slight pubescence in the axils on the under surface; cymes with long peduncles, 2 to 3 inches broad. In moist soil. Ashtabula, Geauga, Lorain, Summit, Stark, Wayne, Ashland, Tuscarawas.

3. **Viburnum scabrellum** (T & G) Chapm. Roughleaf Arrow-wood. A shrub with more or less densely tomentose twigs; leaves $1\frac{1}{2}$ to 5 inches long; $\frac{1}{2}$ to $3\frac{3}{4}$ inches broad, usually tomentose on both sides, crenate or dentate; petioles short and stout; fruit an ovoid, globose, blue drupe. Along river banks and in moist woods. Adams, Brown, Hocking, Madison.

4. **Viburnum cassinoides** L. Withe-rod. A shrub 2 to 12 feet high with ascending branches, more or less gray, often scurfy or glabrate; leaves ovate to obovate, thick, base often narrowed but sometimes rounded, apex acute, margin crenulate, $\frac{3}{4}$ to $3\frac{1}{4}$

inches long, $\frac{1}{2}$ to $1\frac{3}{4}$ inches wide, both surfaces glabrous or nearly so; penduncle shorter or somewhat shorter than the cyme; fruit a pink drupe which turns dark blue, globose to ovoid, $\frac{3}{8}$ to $\frac{1}{2}$ inch long; stone rounded or oval flattened. In swamps and moist places. Ashtabula, Cuyahoga, Geauga, Lorain, Summit, Hocking.

5. **Viburnum lentago** L. Sheepberry. A shrub or small tree; leaves lanceolate to oblanceolate and oval, acuminate, rounded at the base, sharply serrulate, glabrous or only slightly pubescent beneath, 2 to 4 inches long, $\frac{1}{2}$ to 2 inches wide; petioles widened often with a wavy margin; cyme several-rayed, 2 to 5 inches broad; fruit an oval bluish-black drupe with a bloom, $\frac{1}{2}$ to $\frac{3}{4}$ inches long, stone flattened, circular or oval. In rich fields and woods. Rather general.

6. **Viburnum prunifolium** L. Black Haw. A shrub or small tree with reddish-brown pubescence, rather small flattened winter buds; leaves ovate to broad obovate, obtuse to somewhat acute, finely serrulate, usually glabrous, $\frac{3}{4}$ to $3\frac{1}{4}$ inches long, $\frac{1}{2}$ to 2 inches wide; petioles usually not margined; cyme several-rayed, 2 to 4 inches broad; fruit a bluish-black glaucous drupe, $\frac{3}{8}$ to $\frac{3}{4}$ inches long; stone flattened on one side, somewhat convex on the other, ovoid. In dry field and along roadsides. General.

7. **Viburnum lantana** L. Wayfaring-tree. A shrub about 12 feet high; branches densely stellate pubescent; leaves $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long, $\frac{3}{4}$ to 2 inches wide, ovate, serrulate, upper surface dark green, glabrous or only slightly pubescent, lower surface lighter, more or less stellate pubescent beneath, base subcordate; petioles short and stout; cyme short peduncled, many flowered. Escaped in Lake County.

8. **Viburnum acerifolium** L. Mapleleaf Arrow-wood. A shrub 3 to 6 feet high with smooth gray branches and pubescent twigs; leaves ovate, deeply 3-lobed, $2\frac{1}{2}$ to $4\frac{1}{2}$ inches long, $2\frac{1}{4}$ to 4 inches wide, lobes acute or acuminate, orbicular, base cordate or somewhat truncate, both sides pubescent when young later becoming glabrate, coarsely dentate; petioles $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, pubescent; cymes with long peduncles, $1\frac{1}{2}$ to 3 inches broad; flowers all bisporangiate, $\frac{1}{8}$ to $\frac{1}{4}$ inch broad; fruit an oval nearly black drupe about $\frac{1}{2}$ inch long; stone lenticular, slightly two-ridged on one side, two-grooved on the other side. In dry woods. General.

9. **Viburnum opulus** L. Cranberry-tree. A shrub sometimes reaching 12 feet in height; branches smooth; leaves broadly ovate, glabrous above, more or less pubescent along the veins beneath, deeply three-lobed, $2\frac{1}{4}$ to $3\frac{1}{2}$ inches long, $1\frac{1}{2}$ to $3\frac{1}{2}$ inches wide, the lobes acuminate, base truncate or cordate, 3-ribbed; margin coarsely dentate; petioles $\frac{1}{2}$ to $2\frac{1}{4}$ inches long; cyme with sterile outer flowers, large, radiant, peduncled, $3\frac{1}{2}$ to 4 inches

broad; fruit a red globose or oval drupe $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter, very acid, translucent; stone not grooved, flat, orbicular. Low fields and woods. Lake, Geauga, Champaign.

10. **Viburnum alnifolium** Marsh. Hobblebush. A shrub with smooth purplish bark, branches often procumbent, irregular and wide spreading; young twigs often scurfy; leaves orbicular or very broadly ovate, apex short acuminate or acute, base usually cordate, upper surface usually becoming glabrous, lower covered with a stellate pubescence especially along the veins, margin finely serrate, $1\frac{1}{4}$ to $2\frac{1}{2}$ inches broad, $1\frac{1}{2}$ to 3 inches long, petioles $\frac{1}{2}$ to $1\frac{1}{2}$ inches long; cymes sessile, $3\frac{1}{2}$ to $5\frac{1}{2}$ inches broad, outer flowers large usually about one inch in diameter; fruit a red drupe, becoming purple, oblong, $\frac{1}{2}$ to $1\frac{1}{4}$ inches long; stone three-grooved on one side, one-grooved on the other. In low woods. Ashtabula and Lake Counties.

Symphoricarpos [Dill.] Ludw.

Shrubs with opposite branches; leaves mostly entire, simple, short petioled, flowers mostly white or pink, bisporangiate, usually somewhat zygomorphic, tetracyclic or pentacyclic; corolla campanulate or salverform, often somewhat lipped, and gibbous at the base; calyx nearly globular; stamens as many as the corolla lobes; inflorescence axillary or in terminal clusters; ovulary 4-locular, two cavities containing vestigial ovules, the other two each containing a single suspended ovule; style slender; fruit a 2-seeded berry; seeds oblong with a small embryo.

Key to the Species.

1. Leaves usually glabrous, sometimes slightly pubescent beneath; flowers in few-flowered axillary and terminal clusters; style glabrous; berries snow white. *S. racemosus.*
1. Leaves glabrous above, usually soft pubescent beneath; flowers in dense axillary clusters; style bearded; berries purplish red. *S. symphoricarpos.*

1. **Symphoricarpos racemosus** Mx. Snowberry. An erect almost glabrous shrub; leaves oval, obtuse at both ends, glabrous above, sometimes slightly pubescent beneath, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long, $\frac{1}{2}$ to $1\frac{1}{2}$ inches wide, margin entire, wavy, or slightly dentate when young; petioles $\frac{1}{4}$ inch long; flower clusters terminal and axillary, the terminal one irregularly spicate; corolla campanulate, base gibbous, bearded within, style glabrous; fruit a white globose berry about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. In waste places and along river banks. Rather general.

2. **Symphoricarpos symphoricarpos** (L.) MacM. Coral-berry. A shrub 1 to 5 feet in height with purplish usually pubescent twigs; leaves oval to ovate, entire or undulate, glabrous above, usually soft pubescent beneath, $\frac{1}{2}$ to $1\frac{3}{4}$ inches long, $\frac{1}{2}$ to 1 inch

wide; petioles $\frac{1}{8}$ to $\frac{1}{4}$ inch long; flower cluster dense, many flowered becoming spicate; corolla campanulate, pink, somewhat pubescent within, about $\frac{1}{4}$ inch in length; stamens included; fruit a purplish-red globose berry $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. In rocky fields and along river banks. General.

Lonicera L. Honeysuckle.

Erect shrubs or woody climbing vines with oval or ovate, usually entire leaves; flowers often in pairs, spicate, or clustered, bisporangiate, pentamerous, usually zygomorphic; corolla commonly gibbous at the base, somewhat 2-lipped; ovulary 2-3-locular, sometimes 1-locular; ovules many, pendulous; style slender, stigma sometimes capitate; fruit a fleshy berry; embryo terete.

Key to the Species.

1. All the leaves distinct, flowers in pairs on axillary peduncles. 2.
1. Upper leaves connate-perfoliate, flowers in heads or interrupted spikes. 6
2. Shrubs, not twining; cluster small with small, linear to subulate bracts; flowers small, $\frac{3}{8}$ to $\frac{3}{4}$ inch long. 3.
2. Twining vines; flowers large, $1\frac{1}{4}$ to $1\frac{3}{4}$ inches long, white or pink fading to yellow. *L. japonica.*
3. Corolla almost actinomorphic; twigs glabrous; leaves green on both sides. 4.
3. Corolla zygomorphic, more or less 2-lipped; twigs pubescent when young, sometimes becoming glabrous when mature; leaves pale green, lighter beneath than above. 5.
4. Leaves not ciliate; bracts linear; corolla with wide spreading lobes about as long as the tube, white to rose colored. *L. tartarica.*
4. Leaves strongly ciliate; bracts small subulate; corolla lobes shorter than the tube, greenish yellow. *L. canadensis.*
5. Leaves glabrous or nearly so when mature, not ciliate; peduncles $\frac{3}{4}$ to $1\frac{1}{2}$ inches long, slender. *L. oblongifolia.*
5. Leaves persistantly pubescent beneath, ciliate; peduncles $\frac{1}{4}$ to $\frac{1}{2}$ inch long. *L. xylosteum.*
6. Corolla tubular, nearly regular, glabrous; leaves dark green above, slightly glaucous beneath; stamens and style little exserted. *L. sempervirens.*
6. Corolla 2-lipped; upper lip consisting of four lobes. 7.
7. Corolla glabrous within; terminal cluster sessile. *L. caprifolium.*
7. Corolla pubescent within; flower cluster more or less stalked. 8.
8. Leaves pubescent on both sides, very strongly so beneath, only slightly glaucous. *L. hirsuta.*
8. Leaves glabrous on both sides or only slightly pubescent beneath; very glaucous. 9.
9. Leaves glabrous above but pubescent beneath especially along the veins; corolla strongly gibbous at the base. *L. glaucescens.*
9. Leaves glabrous on both sides; corolla tube somewhat gibbous. 10.
10. Corolla tube not much exceeding $\frac{1}{4}$ inch in length; uppermost leaf-disks oblong. *L. dioica.*
10. Corolla tube usually $\frac{1}{2}$ inch long; uppermost leaf-disks orbicular. *L. sullivantii.*

1. **Lonicera canadensis** Marsh. American Fly Honeysuckle. A shrub 3 to 5 feet high with glabrous twigs; leaves ovate to obovate, acute, base rounded or somewhat cordate, upper surface glabrous, under surface soft pubescent when young becoming glabrous when mature, $1\frac{1}{4}$ to $3\frac{1}{2}$ inches long, $1\frac{1}{2}$ to 2 inches wide, margins ciliate; petioles slender, $\frac{1}{4}$ to $\frac{3}{8}$ inch long, flowers in axillary pairs, yellowish green, about $\frac{3}{4}$ inch long, with small subulate bracts, actinomorphic; corolla lobes short; fruit a scarlet ovoid berry about $\frac{1}{4}$ inch thick. In moist shaddy places. Lake, Summit, Cuyahoga, Lorain.

2. **Lonicera oblongifolia** (Goldie) Hook. Swamp Fly Honeysuckle. A shrub with grayish branches; leaves ovate, acute, sometimes rounded, nearly glabrous when mature, downy pubescent when young, margin ciliate; flowers in pairs, axillary, yellow with purple tints within, $\frac{1}{2}$ to $\frac{3}{4}$ inches long, gibbous at the base, zygomorphic, bracts very small or wanting; ovularies distinct or sometimes united; fruit a red berry. In wet places and swamps. Cuyahoga County.

3. **Lonicera tartarica** L. Tartarian Honeysuckle. A shrub with glabrous grayish branches, 5 to 10 feet high; leaves 1 to $2\frac{3}{4}$ inches long, $\frac{1}{2}$ to $1\frac{3}{8}$ inches wide, thin, ovate, acute, base truncate or cordate, not ciliate, flowers in pairs, axillary; corolla pink or white $\frac{1}{2}$ to $\frac{3}{4}$ inch long, gibbous at the base, deeply five parted, somewhat 2-lipped; peduncles $\frac{1}{2}$ to $1\frac{1}{2}$ inches long; bracts linear, rather long; stamens and style somewhat exserted; fruit of separate berries. Along roadsides and meadows; mostly escaped from cultivation. Ashtabula, Lake, Cuyahoga, Lorain, Licking, Franklin, Auglaize.

4. **Lonicera xylosteum** L. European Fly Honeysuckle. A shrub 3 to 7 feet high with pubescent twigs; leaves ovate to obovate upper ones acute, lower ones sometimes rounded or obtuse at the base, margin entire, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long, $\frac{3}{8}$ to $\frac{3}{4}$ inch wide, densely pubescent on both sides when young, and beneath when mature; petioles short, pubescent; flowers axillary with peduncles about as long as the flowers, $\frac{1}{3}$ to $\frac{2}{3}$ inch long, yellowish white, bracts linear-subulate; fruit a scarlet berry. In fields and along roadsides where it has escaped from cultivation. Lake County.

5. **Lonicera japonica** Thunb. Japanese Honeysuckle. A climbing or trailing vine; leaves ovate, acute with rounded base, glabrous above, somewhat pubescent beneath, 1 to 3 inches long, $\frac{1}{2}$ to $1\frac{1}{2}$ inches wide, margin entire; flowers axillary in pairs at the ends of the vines; bracts large and leaf-like; peduncles $\frac{1}{2}$ to $\frac{3}{4}$ inch long, white or pink fading to yellow, pubescent without, 2-lipped; stamens and style exserted; fruit a black berry $\frac{1}{4}$ to $\frac{1}{3}$ inch in diameter. Escaped from cultivation. Adams, Brown, Auglaize.

6. **Lonicera sempervirens** L. Trumpet Honeysuckle. A glabrous high climbing vine; leaves oval, obtuse, ½ to 2 inches long, 1 to 1½ inches wide, lower ones somewhat smaller, sessile, and more ovate than the upper connate-perfoliate ones, upper surface dark green, glaucous, lower surface sometimes rather pubescent; inflorescence a terminal interrupted verticilate spike; corolla scarlet or yellow, usually glabrous sometimes slightly pubescent, 1 to 1½ inches long, its tube narrow, somewhat expanded above the stamens; stamens and style little exserted; fruit a scarlet berry about ¼ inch in diameter. In moist fields or on hillsides. Cuyahoga County.

7. **Lonicera caprifolium** L. Italian Honeysuckle. A high-climbing glabrous or glaucous vine; leaves oval to obovate, rounded, the entire upper ones connate-perfoliate, the lower ones sessile or nearly so, glaucous beneath; flowers in terminal sessile clusters; corolla glabrous and white within, purple without, 1 to 1½ inches long, 2-lipped, upper lip 4-lobed, lower one narrow, reflexed; corolla tube curved; stamens and style much exserted; fruit a red berry. In thickets. No specimens.

8. **Lonicera hirsuta** Eaton. Hairy Honeysuckle. A hairy-pubescent, long, climbing vine; leaves 1½ to 4 inches long, ½ to 1½ inch wide; lower ones sessile or very short petioled, the upper pairs larger and connate-perfoliate, dark green and appressed-pubescent above, lighter and soft-pubescent beneath, ciliate, obtusish, base rounded or somewhat cordate or narrowed; flowers verticillate in terminal interrupted spikes; corolla orange-yellow turning reddish, clammy pubescent without, 2-lipped, slightly gibbous, narrow; filaments hirsute below; stamens and filaments exserted. In swamps, woods, and copses. Ottawa, Lorain, Monroe.

9. **Lonicera glaucescens** Rydb. Glaucescent Honeysuckle. A vine with glabrous branches; leaves dark green and glabrous above, lighter and pubescent beneath especially along the veins, 1½ to 5 inches long, 1 to 3 inches wide, upper pair perfoliate, forming a rhombic disk, obtuse or acute, margin entire, papery; verticillate flowers in terminal interrupted spikes; corolla pale yellow changing to a reddish color, usually pubescent without and within; tube one inch long, gibbous, 2-lipped; stamens nearly glabrous, exserted; ovulary sometimes hirsute. In fields, meadows and woods. General.

10. **Lonicera sullivanti** Gr. Sullivant's Honeysuckle. A very glaucous vine; leaves 1½ to 3 inches long, ¾ to 2½ inches wide, ovate to obovate, upper surface dark green and glaucous, lower lighter and slightly pubescent, obtuse; inflorescence a terminal cluster; corolla pale yellow, tube ½ to ¾ inch long, 2-lipped,

slightly gibbous; fruit a yellow berry about $\frac{1}{4}$ inch in diameter. In woods. Stark, Muskingum, Franklin, Madison, Clark, Highland.

11. **Lonicera dioica** L. Smoothleaf Honeysuckle. A trailing or shrubby plant 3 to 10 feet high; leaves oval to obovate, $1\frac{1}{2}$ to 3 inches long, $\frac{3}{4}$ to $1\frac{1}{4}$ inches wide, usually glaucous beneath, upper pair connate-perfoliate, lower ones sessile, obtuse, base truncate or cordate; inflorescence a terminal cluster; corolla yellowish green tinged with purple, gibbous, 2-lipped, glabrous without, pubescent within, tube $\frac{1}{4}$ to $\frac{1}{3}$ inch long, stamens and style exserted; fruit a red berry $\frac{1}{4}$ to $\frac{1}{3}$ inch in diameter. In dry rocky fields and along roadsides. Champaign, Franklin.

Triosteum L. Horse-gentian.

Perennial herbs with simple, terete, pubescent stems; leaves opposite, perfoliate or sessile, ovate, oblong, or oblanceolate, constricted below the middle, usually pubescent; flowers solitary or in clusters, bisporangiate, 2-bracted, sessile; corolla yellowish, green, or purple, tube narrow, gibbous at the base, campanulate; calyx lobes elongated, linear-lanceolate, leaf-like, persistant; filaments short, anthers linear, included; ovulary 3-5-locular containing a single ovule in each cavity; fruit a coriacious, orange or red drupe containing 2-3 one-seeded nutlets, embryo small.

Key to the Species.

1. Stem slender, hirsute pubescent, $1\frac{1}{2}$ to $3\frac{1}{2}$ feet high; leaves rough pubescent, corolla yellowish. *T. angustifolium.*
1. Stem erect, stout, finely glandular-pubescent, 1 to 3 feet high; leaves soft pubescent, some connate-perfoliate; corolla purple or dull red. *T. perfoliatum.*

1. **Triosteum angustifolium** L. Yellow Horse-gentian. Stem slender, very pubescent, 1 to 3 feet high; leaves lanceolate to oblanceolate, acute to long acuminate, $2\frac{1}{2}$ to 5 inches long, $\frac{1}{2}$ to $1\frac{1}{2}$ inches wide, tapering below the middle to an acute sessile base, roughly pubescent; corolla yellowish, about $\frac{1}{2}$ inch long; flowers axillary, solitary. In fertile places. Cuyahoga, Warren, Clermont.

2. **Triosteum perfoliatum** L. Common Horse-gentian. Stems $1\frac{1}{2}$ to $3\frac{1}{2}$ feet high, covered with short glandular hairs; leaves $3\frac{1}{2}$ to $8\frac{1}{2}$ inches long, $1\frac{1}{2}$ to 5 inches wide, ovate to oblong-lanceolate, acuminate, tapering to a narrow base, often somewhat connate, upper surface appressed pubescent to glabrous, lower quite pubescent; flowers not solitary, $\frac{1}{2}$ to $\frac{5}{8}$ inch long, corolla lobes rather large, somewhat spreading; stamens and style moderately exserted; calyx lobes linear, obtuse; fruit an orange-red drupe about $\frac{3}{8}$ to $\frac{1}{2}$ inch long. In rich soil. General.

Linnæa L.

Small creeping rather woody herbs; leaves evergreen, petioled, obovate to orbicular; flowers in pairs, long peduneled, pink or purple, bisporangiate, campanulate to funnelformed, actinomorphic; andreecium pentamerous, united with the base of the corolla, included; ovulary 3-locular, one cavity containing a perfect ovule while the others have several rudimentary ovules; fruit almost globose, containing a single long seed.

1. **Linnæa americana** Forbes. American Twinflower. Branches woody, slender, somewhat pubescent, trailing; leaves $\frac{1}{4}$ to $\frac{1}{2}$ inch long, $\frac{1}{4}$ to $\frac{3}{8}$ inch wide, usually somewhat crenate, slender, petioled, erect; peduneles about 3 inches long, 2-bracteolate at the tip; flowers funnelform, fragrant, $\frac{3}{8}$ to $\frac{1}{2}$ inch long; ovulary subtented by two glandular ovate scales which often cover the fruit and are attached to it. In cool places. Stark County.

Diervilla [Tourn.] Mill. Bush-honeysuckle.

Shrubs with opposite leaves and yellow cymose or solitary bisporangiate flowers; corolla narrow funnelform, nearly actinomorphic, base somewhat gibbous; calyx tube slender narrow below; stamens five, anthers linear, ovulary bilocular; ovules many, seed coat minutely reticulate; fruit a glabrous, slender, beaked, septicidal, many seeded capsule; embryo minute.

1. **Diervilla diervilla** (L.) MacM. Bush-honeysuckle. A shrub $1\frac{1}{2}$ to 3 feet high; branches glabrous or nearly so, terete usually with two pubescent ridges; leaves short petioled, ovate to obovate, acuminate, irregularly crenate, sometimes slightly ciliate; flowers terminal or in upper axils in 1-5-flowered clusters; corolla about $\frac{3}{4}$ inch long, pubescent, very slightly 2-lipped. In rocky dry woods. Lucas, Lorain, Summit, Wayne, Stark, Franklin.

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THE CHEESE SKIPPER. (Piophila casei Linné.)* 1.

AN ACCOUNT OF THE BIONOMICS AND THE STRUCTURE OF DIPTEROUS LARVAE OCCURING IN HUMAN FOODS WITH PARTICULAR REFERENCE TO THOSE WHICH HAVE BEEN RECORDED AS ACCIDENTAL PARASITES OF MAN.

DON C. MOTE.

The cheese skipper, Piophila casei Linne, is, because of its habits, of considerable economic importance to man. Manufacturers of cheeses and smoked meats have sustained large losses from the ravages of the larva of this fly. Cases are on record where from $1500 to $2000 have been lost in one season. The possible relation of this fly to myiasis increases its importance. The Bureau of Entomology, U. S. Department of Agriculture, has one record of its occurence in man. Alessandrini reports, as a result of experiments with this species on dogs, that it passes through the digestive tract uninjured and that it may cause intestinal lesions in the dog. It is therefore desirable that medical men, public health officers, meat inspectors, and parasitologists have a knowledge of the anatomy and breeding habits of this fly. The investigations upon which this account are based were begun at the Ohio Experiment Station in September 1912, when the larval stage of the cheese skipper was brought to the laboratory in some bacon that had been purchased of a local meat dealer. The bacon was placed in a jar and has with an additional quota of bacon, nourished many broods of larvae.

*Determined by Professor J. S. Hine.

The Egg. Figs. 3 and 4.

The egg is cylindrically oval, slightly narrowed posteriorly; dorsal side, concave; ventral side, convex; lateral sides, somewhat parallel. A gelatinous cap covering the micropyle is situated upon the anterior end. Length .68 mm to .75 mm. Width .18 mm to .2 mm. (10 eggs).

The chorion is smooth, partially transparent, pearly white. A delicate mosaic work of regular pentagonal facets was observed upon a small portion of the chorion of one egg. The others were covered with some material which probably obscured the sculpturing.

In the breeding jars the eggs were found on bacon, sweitzer cheese, ham and slightly putrid beef-steak, rarely in clusters, being, as a rule, scattered singly over the surface pointing in various directions. No eggs were ever found upon the sides of the jars.

Duration of the egg stage 23 to 54 hours. Temperature range 60° to 80° F. Normal saline solution will hasten the hatching process. The chorion collapses after the larva emerges.

The Larva. Figs. 6-14.

The Larva may be observed through the partially transparent chorion several hours before hatching. When ready to emerge the anterior end of the egg shell is pulled back slowly, receding about $4\frac{1}{2}\,\mu$, and is then suddenly shoved forward. After several of these backward and forward movements, the egg-shell splits across the anterior end and back on the sides a distance of about .2 mm. (Fig. 5.) Through the opening thus made the larva emerges. The larvæ are active immediately after they emerge from the shell.

The newly hatched larvæ measure, when fully extended, from .8 to .88 mm. long; when contracted .7 to .75 mm. long. Width .1 to .15 mm. To the unaided eye, the young larvæ, except for the black chitinous mouth parts, are white. Under the binocular they have a dusky granular appearance. Through the partially transparent integument the two main tracheal tubes, for their entire length, are visible.

In shape, the larvæ are cylindrical, blunt at the posterior end, tapering gradually toward the anterior end. The segments are as distinct and of the same number as in the mature larvae. The integument is smooth and devoid of vestiture, except for three faint transverse, irregular rows of black chitinous teeth or spines on the antero—ventral portion of each of the 7 segments, posterior to and including the sixth segment.

The cephalic segment is bilobed, each lobe bearing on its antero—dorsal surface an antennal tubercle. Between the oral lobes extend the paired falcate mouth-hooks. The cephalo-pharyngeal skeleton extends nearly the length of the first two

segments. Except for its slenderness and smaller size, the cephalo-pharyngeal skeleton is similar to that in the adult larva. The tracheal trunks open to the exterior through two anterior and two posterior spiracles, similar in structure and position to those of the mature larva. On the caudal segment are found the two posterior, two dorsal, and the paired angular lateral projections present in the adult. The paired angular lateral projections are not so promiinent as in the mature larva.

The full grown larva (Fig. 7) measures 9 to 10 mm. in length, and about 1 mm. in width (5 live specimens). Preserved specimens measure 8 to 9 mm. in length, 1.17 mm. in width, and .9 to 1.17 mm. in height. General shape of larva is cylindrical; truncate at posterior end; tapering gradually to a bilobed, narrower anterior end. Widest portion in the region of the 7th and 8th segments. To the unaided eye the general color is white to yellowish white; under the binocular yellowish-white to brown, especially in the regions posterior to the 4th segment. The tracheal trunks, the black chitinous mouth parts, and viscera are visible through the integument. Except for the three irregular transverse rows of spines already mentioned, the integument is smooth. The body of the larva is divided into thirteen segments.

The bilobed cephalic or pseudocephalic segment is .15 mm. wide. The antennal tubercle (Fig. 13) located on the antero-dorsal surface of each of the oral lobes consists of three segments and measures .026 mm. long by .017 mm. wide at its base. The cephalo-pharyngeal skeleton (Fig. 14), visible through the integument, extends from the ventral middle portion of the pseudo-cephalic segment to the posterior part of the second segment. It consists of two uncinate mandibular sclerites (m. s.). These articulate posteriorly with the hypostomal sclerite (h. s.). The hypostomal sclerite consists of two irregular lateral bars united by two ventral bars of chitin. Posteriorly the hypostomal sclerite articulates with two processes on the anterior edge of the lateral pharyngeal sclerites (l. p.). Each of the lateral pharyngeal sclerites are wider posteriorly than anteriorly, and the posterior is deeply incised. They are united dorsally at the anterior end by a dorsal sclerite (d. p. s.) and ventrally they are continuous with the floor of the pharynx.

The caudal end of the larva (Fig. 8) measures .77 mm. wide and .71 mm. high (preserved specimens). On the posterior surface of the last segment and ventral to the caudal spiracles are located two fleshy tubercles .17 mm. apart (p. t.); each tubercle measures .13 to .17 mm. long and .068 wide at base. On the dorsal surface of each spiracular lobe is a fleshy tubercle (d. t.) measuring .05 mm. in length by .025 mm. in width. On the lateral surfaces of the last segment are located paired angular-like projections, (l. an.) measuring about .05 mm. long by .068 to .085 mm. wide at the base.

The tracheæ open to the exterior through two anterior and (a. s. p.) two posterior (p. s. p.) spiracular processes. The anterior or prothoracic spiracles (Fig. 13) are situated laterally at the posterior of the second body segment. Each spiracle consists of from 8 to 10 short, rounded lobes. The posterior spiracle (Figs. 8, 9, 12) are each situated at the ends of two very short fleshy projections from the dorsum of the terminal body segment. They are .12 mm. apart and so situated that they face each other. When the caudal segments are retracted, the spiracular lobes become less prominent and the stigmata become closely apposed. The posterior end of the tracheal trunk divides into three parts, each part possessing a stigmatic orifice. (Figs. 8, 9.).

The larval instar extended over a period of fourteen days. (average temperature 67 deg. F.) Larvæ were reared on bacon, sweitzer cheese, ham, fresh lean or fat beef possessing a slight putrid odor. Murfeldt and others report that it occurs in cheese, ham, especially the fatty parts, and oleomargarine. In addition to the usual method of locomotion of the cruciform larva, these larvæ at times leap or skip through the air. They accomplish this, to use the apt description of Prof. Putnam, by "bringing the under side of the abdomen toward the head while lying on their sides and reaching forward with their head and at the same time extending their mouth hooks, grapple by means of them with the hinder edge of the truncature, and pulling hard, suddenly withdraws them, jerking its self to a distance of 4 or 5 inches." The larvæ do not necessarily in preparing for the jump, have to lie on their sides. They may form the loop with only the tips of the caudal and cephalic ends touching the surface of the substance upon which they are feeding. One larva under observation sprung at least 4 inches high and a linear distance of about 6 inches.

Prior to pupation, the larvae left the substances upon which they were feeding and crawled in between the cotton plug and sides of the vial. This took place about 32 hours before the pale to dark brown coarctate puparia were formed. The puparium (Fig. 15) mesaures 4 to 5 mm. long by 1 to 1.7 mm. wide. Its general shape is ovate, with the caudal end obliquely truncate, and the antero-dorsal surface convexly and gradually depressed from about the 6th segment. The ventral transverse spines are observable as one heavy dark regular row and two paler less regular rows. The cephalic segment is slightly bilobed. The anterior spiracles are lateral to this segment. The posterior tubercles are very prominent. Above these are the stigmatal lobes, upon the dorsal surface of which are the dorsal tubercles. The pupal instar extended over a period of 12 days. Several entomologists have observed shorter periods than this, from 1 week to 10 days, and it is not unlikely that under adverse condi-

tions longer periods occur. In fact, it is probable that larvæ developing late in the season pass the winter in the pupal stage. The imago emerges by splitting off the antero-dorsal depressed area. (Fig. 16.)

The Adult. (Figs. 1, 2.)

The specific description of **Piophila Casei** Linne is inaccessible to the writer. The following, therefor, is a redescription of the species based upon only a dozen or so specimens and consequently is not as complete as it should be.

Male:—The dominant color is bronzy black; length to tip of abdomen 3.4 mm. to 3.9 mm.; to tip of wings 4.4 mm. to 4.5 mm.

Head (Fig. 2): Palps and proboscis fuscous, covered with many bristles. Face, yellow to fuscous, excavated; antennæ short, not reaching to oral margin, fuscous, non-porrect; non-setose arista; short bristle on second segment of antenna; cheeks, yellow to fuscous. Front fuscous immediately above the antennæ to bronzy black beyond; vertical triangle smooth, shiny black, bears three ocelli and a pair of ocellar bristles just posterior and lateral to anterior ocellus; compound eyes bare, color red. Bristles: vibrissae present; also several bristles on lower edge of each cheek; post orbital bristles present; vertical bristles 2 pair, anterior pair erect convergent, posterior not as erect, divergent; post-vertical bristles extend over thorax, slightly divergent; fronto-orbital, a series of short bristles extending from a point just anterior to the vertical bristles to a point above and opposite the base of the antennæ. Row of very short bristles on ridge around antennal pit extending from vibrissæ on the left, around base of antennæ to the vibrissæ on the right.

Thorax: Bronzy black with 3 distinct rows of regularly placed short setæ; Scutellum, same color, bears 2 pairs of long setæ or bristles and several transverse parallel rows of short setæ, not easily observed. Sides,—same color, each bearing several long setæ. Legs: Covered with short spines; coxa yellow to fuscous; femur, fuscous at joints, middle blackish-brown. Anterior leg,—tibiæ, except at proximal joints, and tarsi, blackish-brown. Middle and hind legs,—Tibiæ blackish-brown to fuscous, fuscous at joints, tarsi fuscous.

Abdomen: Rectangular, sides somewhat parallel, tip blunt. Same color as thorax. Six visible segments, each bearing many short spines.

Wings: Overlap nearly to tips when fly is at rest. Wholly hyaline, irridescent, auxiliary vein indistinct or closely apposed to the sub-costa; halteres, pale yellow.

Female:—Same color as the male. Length to tip of abdomen 3.9 mm to 4.1 mm; to tip of wing 5 mm. to 5.2 mm. Abdomen,—six visible segments, pyriform.

Miss Murtfeldt was unable to get the female to oviposit on flesh meat of any kind. In the writer's experience, fresh beef-steak with a slightly putrid odor seemed to be the most desirable. Copulation was observed on the 3rd or 4th day after emergence of the imago and egg deposition on the third day after copulation. The adults lived from 4 to 10 days, the former being the length of life of flies without food and moisture, except at beginning; the latter, the length of life of flies in a small vial, containing slightly putrid steak and plenty of moisture. The females outlived the males.

Because of its breeding habits and the ease with which it is kept in captivity, this species should make a suitable one for the experimental zoologist. A few observations and inconclusive experiments were made on the reaction of the fly to heat, light, gravity and different food substances. When a jar of flies was placed near the window the majority gathered on the lighter side After shaking or otherwise disturbing the same reaction followed. They also almost invariably alight with head pointing upward. They can be transferred from one vial to another by holding the bottom of the empty one towards the light. Deadened by cold, they can be revived by heat.

The following is a report of an experiment to test the comparative value of cheese, bacon, fresh beef-steak and ham as an attraction for the flies. The apparatus consisted of 7 vials and corks thru which were fitted glass tubes with lumens large enuf for the admission of the flies. One of the vials contained cheese; one fresh lean steak; one fresh fat steak; one fat bacon; one lean bacon, one fat ham, one lean ham. The vials were placed in holes in a circular piece of card-board and this card-board containing the vials was placed in a large jar. About 60 flies were admitted from the stock culture, the jar was then covered with a glass plate and placed so that the openings of the tubes leading into the vials would face the light. The flies immediately swarmed upon the glass cover which was facing the window. On the afternoon of the first day there were three flies in the vial containing the cheese, one in the vial containing the lean ham and one in the vial containing the fat ham. At noon on the second day there was one fly in the fresh lean steak vial, one in the fresh fat steak vial, four in the cheese vial, six in the fat ham vial and three in the lean ham vial. On the afternoon of the second day there were five in the fresh lean steak vial, two in the fresh fat steak vial, 5 in the cheese vial, 7 in the fat ham vial and 3 in the lean ham. The steak from which the fat and lean pieces in the vials was taken, was observed at this time to be giving off a slightly putrid odor. At noon on the 3rd day, there were 12 flies in the lean fresh meat vial, 4 in the fat fresh meat vial, 8 in the fat ham vial, 2 in the lean ham vial and 5 in the cheese vial. At noon on the 5th day the

experiment was closed with 22 dead flies in the jar; 16 (one of which was dead) females in the fresh lean meat vial; 6 live flies in the fat fresh meat vial, none in the fat bacon vial, none in the lean bacon vial, 6 ♀s, 3 ♂s, (4 of which were dead) in the fat ham vial, 2 dead males were found in the lean ham vial, 3 ♀s and 1 dead male in the cheese vial. Many eggs were found in the fresh lean and fat steak vials, the fat ham vial and the cheese vial. It would seem from this experiment that the lean fresh steak, possessing a slightly putrid odor has a greater attraction for the flies than the other substances used.

SUMMARY.

The cheese skipper because of its ravages on cheeses and smoked meats and its possible relation to myiasis is of considerable economic importance.

The fly deposits its eggs upon bacon, cheeses, smoked ham, slightly putrid beef-steak. Duration of egg stage 23 to 54 hours.

Larvæ feed upon bacon, cheese, ham, beef, oleomargarine. This insect gets its common name from the peculiar leaping or skipping habit of the larva. Duration of larval instar 14 days.

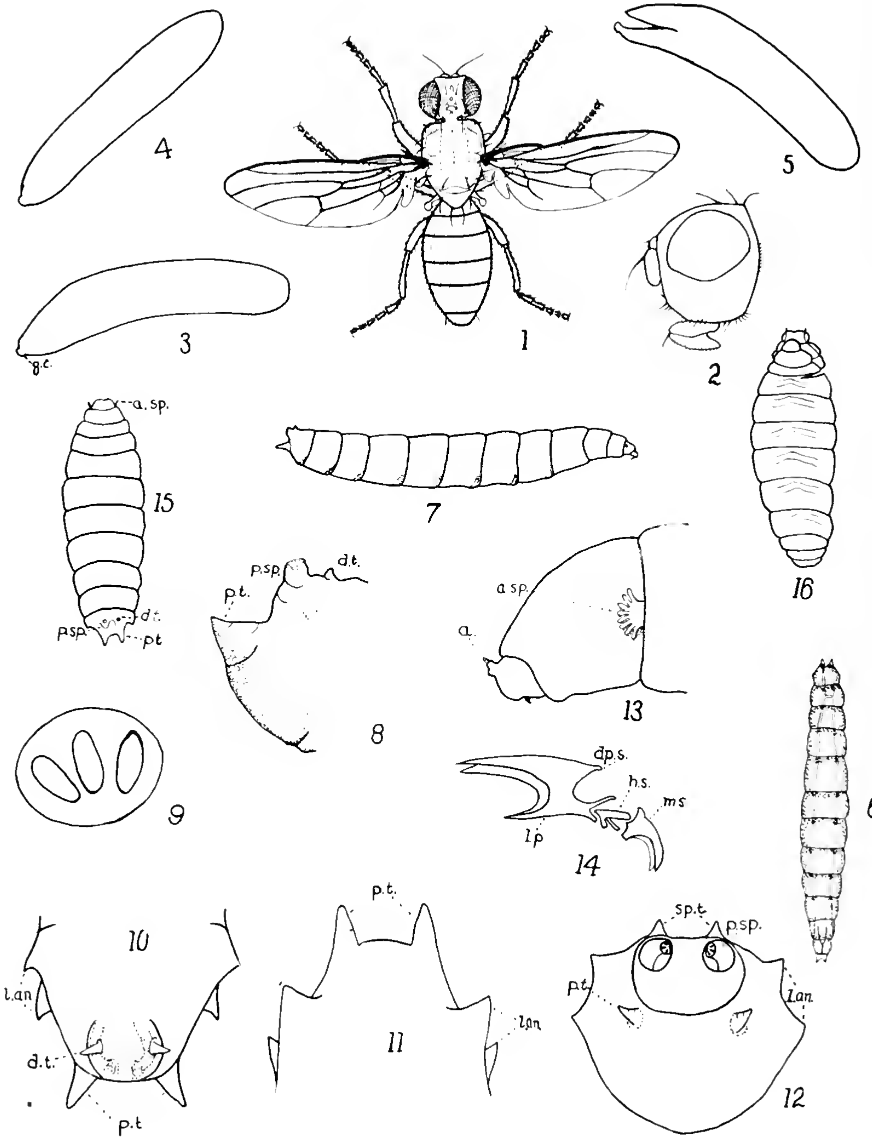
Pupation occurs in dryer places than those in which the larvæ feed. Duration of pupal stage 12 days.

The flies, in an experiment, seemed to prefer beef-steak with a slight putrid order, in preference to ham, bacon or cheese, for egg deposition. The adult flies lived longer, and the larvæ fed and matured more readily, on the beef steak than on the other substances.

EXPLANATION OF PLATE XIV.

Fig. 1. Adult fly about 8 times natural size.
Fig. 2. Profile of head of fly X 20.
Fig. 3. Lateral view of egg X 50, g. c. gelatinous cap.
Fig. 4. Dorsal view of egg X 50.
Fig. 5. Egg after emergence of larva.
Fig. 6. Immature larva X 50.
Fig. 7. Mature larva X 5.
Fig. 8. Lateral view of caudal end of larva X 40, p. t., posterior tubercle; p. sp. posterior spiracle. d. t. dorsal tubercle.
Fig. 9. Posterior view of Caudal spiracle X 400.
Fig. 10. Dorsal view of caudal end of larva X 35; l. an. lateral angular projections, d. t. dorsal tubercle, p. t. posterior tubercle.
Fig. 11. Ventral view of caudal end of larva X 35.
Fig. 12. View of posterior end of larva X 40, Sp. t. dorsal tubercles. p. sp. posterior spiracles, l. an. lateral angular projections, p. t. posterior tubercles.
Fig. 13. Lateral view of anterior end of larva X 50, a. sp. anterior spiracle, a. antenna.
Fig. 14. Mouth parts much enlarged, m. s. mandibular sclerites, h. s. hypostomal sclerites, l. p. lateral pharyngeal sclerites, d. p. s. dorsal pharyngeal sclerites.
Fig. 15. Dorsal view of puparium X 8; d. t. dorsal tubercle. p. sp. posterior respiratory organ. p. t. posterior tubercle.
Fig. 16. Pupal case after emergence of fly.

Ohio Experiment Station.



Mote on "The Cheese Skipper."

STARCH RESERVE IN RELATION TO THE PRODUCTION OF SUGAR, FLOWERS, LEAVES, AND SEED IN BIRCH AND MAPLE.

Forest B. H. Brown.

American scientific literature is lacking in a standard treatment of subjects dealing with the stored reserve in our fruit and forest trees, such as have been made by Büsgen in his "Waldbäume," and in other still more recent German publications. The work of Jones and others of Vermont (Bull. 103, 1903) contains much information on the maples. But this work does not furnish the drawings essential to a clear presentation of starch storage, and the description is inadequate. Even in this bulletin, no attempt is made to show in what way the vast amount of potential energy represented in the stored starch is used, otherwise than in the production of sugar, while the authors themselves conclude that rarely is there used, in this way, more than 4% of the total starch stored in a tree.

This fact, together with the very conflicting statements made in the available published records, has led the writer to publish these few preliminary studies. The ease with which such studies may be carried on, together with their direct bearing upon many of the vital problems of forestry and various branches of agriculture, would suggest their general fitness to be included in the botany laboratory course, even in the high school possessed of only one microscope.

Data for the present paper were taken from selected trees of birch and maple growing on the Ohio State University campus. Particular attention was given to a sugar maple, Acer saccharum Marsh., north-west of the law building. From a 1-year twing of this tree, a cross-section 20 mic. in thickness was cut April 1, by means of a sliding microtome, stained one minute in iodine, and then mounted in glycerine. A camera drawing was made, Fig. 1, the magnification being shown by the accompanying scale. Similarly, a section was cut from a root 8 mm. in diameter, Fig. 2. The granules of starch have been indicated in solid black. In the stem the starch grains are shown in the medullary rays (u. m. and b. m.), wood parenchyma (w. p.), and in all the primary xylem tissues except the vessels. The wood fibres were empty in all the sections studied; but in the root, the wood fibres, as well as the wood parenchyma and medullary rays, are filled. Also, many of the tissues of the bark, both of stem and root, contain starch. Beginning with the first layer inside the cork, they are, in order, as follows: the periderm, collenchyma, thin walled parenchyma, bast parenchyma, and bast rays. The maple, however, contained less starch at this period in the bark tissues than the birch

and other starch trees examined. In the sections illustrated, it is apparent that more starch is stored in the root tissue than in the stem; but the relative volume of stem and root would have to be known, before it would be possible to determine whether a greater absolute volume of starch is stored below than above ground.

It is now the purpose to record, as far as possible, in what manner the starch thus stored is used. In this connection, there are at least five considerations: as, (1) the amount used when a tree is tapped, (2) the amount used when the flowers are formed, (3) when the leaves are formed, (4) when wood is formed, (5) when a heavy "seed year" occurs. Of these, seed production is to be given special attention, since the maple, in common with most of the Ohio forest trees, is known to have regularly recurring periods of heavy seed production. The particular tree chosen is a carpellate tree, and, from its numerous flower buds, it is predicted that the current year is to be a "seed year." (1) and (2) are now complete and it seems best to give results in this paper, rather than delay until all is finished.

To test the sugar production, the seven tree species tabulated below were tapped in a manner somewhat similar to the way the birch is tapped in Russia. Borings 1½ inches deep were made by a drill $\frac{1}{8}$ inch in diameter, and a straw, cut from a thrifty stem of wheat, of a diameter to fit the hole snugly, was inserted far enough merely to penetrate the bark. One-pint Mason jars with water-proof card board caps, perforated to receive the straw, were suspended to collect the sap. 500 to 1000 grams of sap were collected from each tree, evaporated in a large porcelain evaporating dish in the laboratory, and the following percentages of sugar determined:

Species	Date	Per cent sugar in sap	Grams sap per hour	Grams sugar per hour
1. Acer nigrum Mx..	April 6	2.7%	250 g.	6.7 g.
2. Acer saccharum Marsh...	April 9	2.4%	62 g.	1.5 g.
3. Acer platanoides L..	April 9	2.2%	35 g.	.8 g.
4. Acer saccharinum L....	April 7	2.1%	125 g.	2.6 g.
5. Acer negundo L......	April 6	1.7%	500 g.	8.5 g.
6. Betula alba L....	Mar. 31	1.2%	62 g.	.7 g.
7. Betula papyrifera Marsh.	April 4	1.1%	100 g.	1.1 g.

The birches produced a clear, amber colored, wax-like sugar, which does not granulate. The per cent is less than in any of the maples. In Russia, the birch is quite generally tapped. Sometimes this sap is fermented to make birch wine. Of the maples, Acernigrum Mx., the black maple, had the greatest concentration of sugar in the sap, which confirms the statement in Bull. 516, U. S. Dept. Ag., p. 8. But the box elder, Acer negundo, a

small tree on the south bank of "Mirror Lake," while producing a sap of lowest concentration, yielded more sugar per hour than any other of the maples. Under the varied conditions of the experiment, all maples produced a clear creamy white sugar in which little difference in taste was noticed, although the silver maple, No. 4, was in flower at the time. The average concentration of sugar in the sap for the maples was 2.2 %. These results, together with those of Professor Jones, make it probable that the Bonn Text Book is in error in rating the average % for the North American maple at ½ of 1%. The average yield of maple sugar per hour was 4 grams.

At the close of the sap run, April 10, there was almost no corrosion of the starch granules in any of the woody tissues of the sugar maple. There was little starch in any of the tissues of the bark of the young twigs; but starch was still abundant in the same tissues of the root. On April 24, the flowers had fairly opened, and were so numerous as to give the crown of the tree a general green color. Starch had been used from the branches examined, which showed less than 9 annual rings of wood.

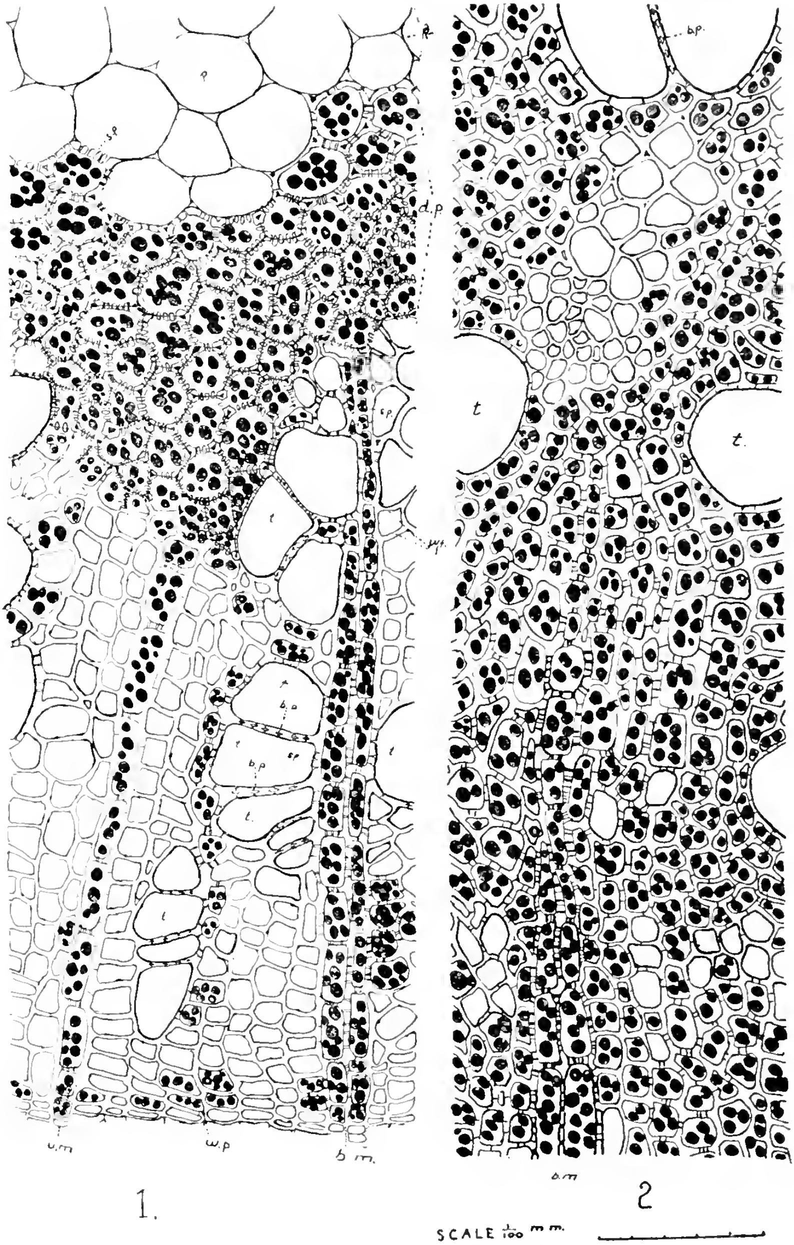
In summary, it may be stated that, previous to bud growth, little starch had been used, the most pronounced changes being confined to the bark of the stem. While buds were swelling, the starch was used from twigs showing less than 3 annual rings of wood. By the time flowers were fully formed, starch had been used from all portions of the stem showing less than 9 annual rings of wood. In other words, starch has been used first from the 1-year old twigs; then, from those portions of the branch showing two annual rings of wood; then, from portions showing 3 annual rings, and so on progressively down to that portion of the branch showing 10 years of wood. Beyond this, as in the root, no marked changes have occurred as yet.

I am indebeted to Mr. H. Udovitch, who has generously aided in collecting data in the flow of sap, and who has supplied the information concerning the use made of the birch in Russia.

EXPLANATION OF PLATE XV.

Figure 1. Cross-section of 1-year old twig.
Figure 2. Cross-section of root.

u. m. uniseriate medullary ray.
b. m. biseriate medullary ray.
t. trachea.
d. p. differentiated pith zone.
p. undifferentiated pith cell.
w f wood fibre.
w. p. wood parenchyma.
b. p. bordered pit in section.
s. p. simple pit in section.



Brown on "Starch Reserve."

EGG-LAYING OF THE RICE WEEVIL, CALANDRA ORYZAE LINN.

FRANK H. LATHROP.

The Rice Weevil, *Calandra oryzæ* Linn., is well known throughout the United States as a stored grain pest. It is especially destructive in the South, however, where it is known chiefly because of its injury to corn (1, 4). In fact, it is often locally called the Corn Weevil.

While studying the pest, the writer was impressed by its highly adaptive method of oviposition, and the belief that a study of the habit would be interesting and of some economic importance led to the observations included in this paper.

The work was performed at Clemson College, South Carolina, during the winter of 1912-1913, under the direction of Professor A. F. Conradi, State Entomologist, to whom the writer is indebted for valuable suggestions and assistance. The cuts are used through courtesy of the South Carolina Experiment Station.

WHERE THE EGGS ARE DEPOSITED.

Each egg is deposited singly in a cavity previously dug in the grain by the female beetle. Preparatory to oviposition, the weevil moves over the surface of the corn several times, examining it thoroughly by means of the tip of the proboscis and the antennæ before a suitable place is decided upon. When the place has finally been chosen, the excavation of the cavity is immediately begun by gnawing the material with the mandibles. Unless disturbed, the weevil will usually finish the cavity when once started, but its completion is by no means certain, for the weevil often becomes apparently dissatisfied with the location even after the cavity is well started, and a new location is sought.

The place selected is usually near the edge of the corn, and, when in position to excavate, the weevil is almost invariably straddling the edge of the kernel. Nearly all of the eggs observed were deposited in the soft starch or in the germ. Only rarely was one placed in the horny starch, while a favorite location was at the junction of the germ with the soft starch, and also at the junction of the soft starch with the horny starch.

In order to facilitate observation, the weevils were provided with grains of corn that had previously been cut in two longitudinally. The eggs were deposited on the broken surfaces of these half-grains, except in a few cases where they were deposited in the germ at the point where it had been attached to the cob. The outer, horny surface of dry corn is apparently too hard for the weevils to penetrate, for no eggs were observed in this region, and, even when only whole grains were provided, the eggs were deposited either in the germ or in the soft starch at the outer end of the kernel.

EXCAVATING THE CAVITY.

While excavating the cavity, the insect retains a firm attachment to the corn by clasping the surface, chiefly with the spines on the distal ends of the tibiæ. During the entire process, one of the fore legs is in almost constant motion as though endeavoring to obtain a better foothold. The operation of digging is accomplished by giving an oscillating motion to the thorax on the first pair of legs as an axis, which results in an up-and-down movement of the proboscis. At the same time, the head is turned from side to side, thus adding a rotary motion to the proboscis. This operation continues until the hole is partially dug, when the proboscis is lifted nearly to the surface, after which the sides are

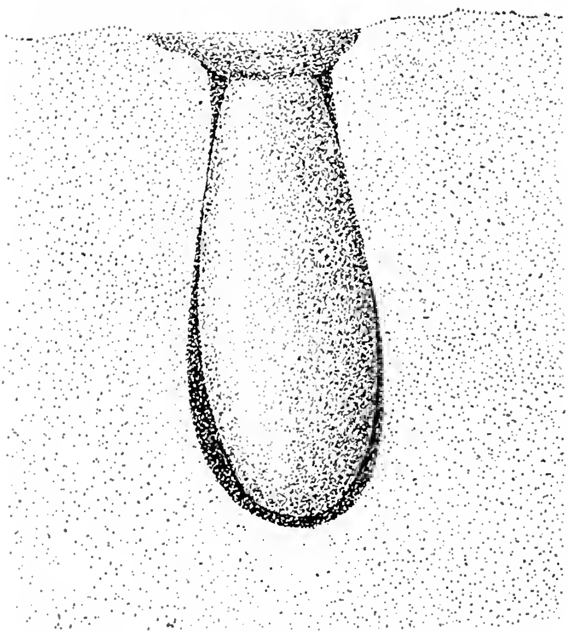


Figure 1. Longitudinal section of cavity showing egg and plug in place.

cut down, enlarging the excavation. When the bottom is again reached, the former movements are resumed. These movements often end with sharp jerks as though pieces of the material were being broken off. The work of excavating is continued until the depth of the cavity is equal to the length of the proboscis, when the weevil stops digging, and prepares to deposit the egg. During the process of digging, that part of the proboscis that extends into the cavity is clean, but chewed material collects about the mouth of the cavity and on the portion of the proboscis above.

The insects are quite easily disconcerted. They discontinue operations and remain still a few moments when disturbed by noise or by the movement of a nearby object, and frequently quit the place entirely. This sensitiveness abates as the cavity deepens, until, during the operation of depositing the egg, the grain on which the weevil is at work may be handled without disturbing the insect.

The time required in making the cavities varies greatly. Out of six operations of which the time was taken, the shortest was thirty two minutes, while the longest period observed was one hour and forty five minutes, and this time was spent in completing a cavity which was apparently one-half finished when observation began.

DEPOSITING THE EGG.

When the cavity is finished, the proboscis is slowly and hesitatingly withdrawn. The weevil then turns around over the opening, and walks slowly forward a few steps, at the same time swinging the abdomen from side to side, thus searching for the mouth of the cavity. When the tip of the abdomen comes in contact with the opening, the weevil stops, and places the ovipositor in position. During egg-laying, the ovipositor may be observed somewhat distended by the passage of the egg. There is a slight movement of the tip of the abdomen, probably aiding in forcing the egg into the cavity.

In one instance it was observed that a weevil, when the cavity was finished, turned about as usual, but failed to find the opening with the ovipositor. The insect then moved backward until the proboscis was over the cavity, facing in the opposite direction from that when the cavity was dug. After a little additional digging, the weevil successfully inserted the ovipositor, and deposited the egg.

The time consumed in depositing the egg varies from three to seven minutes, the average being 4.3 minutes. The average number of eggs laid per day by a single weevil was found to be 1.2. This was determined from records including twenty weevils laying a total of 378 eggs. The largest number of eggs deposited by a weevil in one day was 9, while 63 eggs in 46 days was the greatest total number of eggs deposited by one weevil. This does not represent the total number of eggs laid during the life of the insect. The rate of oviposition as well as the total number of eggs deposited varies with the conditions under which the eggs are laid. Probably the most important factors are the degree of hardness of the corn and the temperature and moisture conditions. Hinds and Turner (3) found that a single weevil is capable of laying as many as 417 eggs during a period of 110 days.

The act of preparing the cavity and depositing the egg apparently requires considerable energy, for, after depositing an egg, the weevil requires a period of rest before repeating the operation.

SEALING THE CAVITY.

After the egg has been deposited, but before the ovipositor has been withdrawn, the substance with which the cavity is sealed may be seen flowing through the translucent ovipositor into the cavity. The ovipositor is then withdrawn, and its trowel-like tip is used to work the fluid into place. This consists of a thorough tamping of the material and smoothing of the surface, and continues until the fluid solidifies. This process being completed, the weevil, without changing position, usually deposits a second

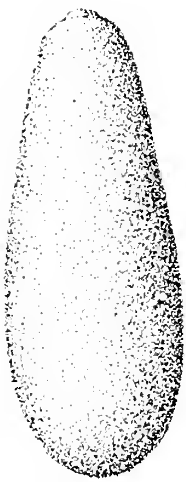


Fig. 2. Egg.

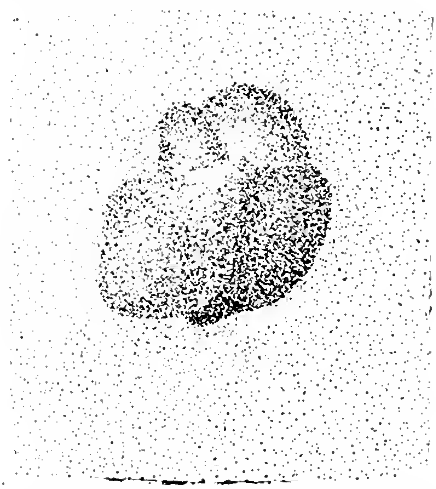


Fig. 3. Plug with two or more discharges of material, viewed in normal position in corn.

mass of material over the first. The second discharge is much less plastic than the first, and is not usually very thoroughly worked with the ovipositor, except when the surface of the first discharge lies below the surface of the corn. Frequently a third mass of material similar to the second, but much smaller, is discharged. This is rarely tamped. After this, the weevil pays no further attion to the egg, but immediately abandons the place.

DESCRIPTION OF THE PLUG.

The plug that seals the cavity may be described as a rather uneven disc-shaped body about .12 mm. thick, the diameter corresponding to the diameter of the mouth of the cavity. The inner surface is somewhat hemispherical, with a minute pit in the centre

into which the tip of the egg extends. In some cases there is also a depression in the outer surface. As the second and third discharges are usually not well tamped, they are seen as rough and uneven masses above the first discharge. When the latter discharges are not present, the surface of the plug has a smooth appearance, and in the rather exceptional cases when the other discharges are well tamped, they also present a fairly smooth surface.

The top of the first discharge usually lies even with the surface of the corn. However, it not infrequently happens that the egg is set so far into the cavity that the top of the plug lies some distance below the surface of the corn, but it never extends much above the surface unless more than one discharge has been added.

Fig. 4. Plug showing pit in inner surface.

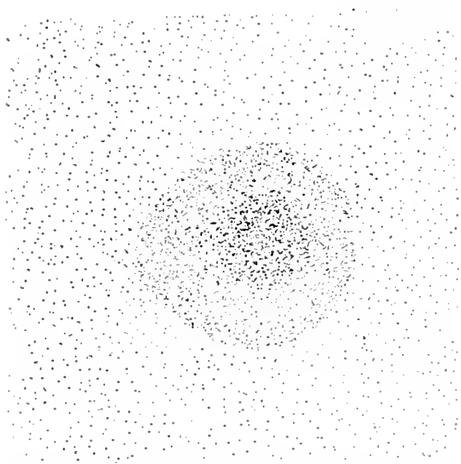


Fig. 5. Plug consisting of a single discharge of material, viewed in normal position in corn.

The plug may readily be picked from the corn by means of a needle. The several discharges are usually very loosely coherent, but, if the second and third discharges have been thoroughly tamped down upon the first, all are more or less firmly united. Usually it is not difficult to separate the plug from the egg, but frequently they are so firmly joined that the egg is torn in separating the two.

The material of the first discharge is colorless and translucent, while that of the second and third discharges is opaque, and varies in color from greenish or yellowish to a starchy white, and closely resembles fæcal material. Hence, if the plug consists of only the first discharge, its apparent color varies with the color of the part of the corn in which it is situated. There often appears to be a dark area in the center of such a plug, which is no doubt caused

by the dark cavity beneath. The plug often so closely resembles the surrounding surface as to be very difficultly distinguished, and some practice is required to locate these eggs. If more than one discharge is present, however, the plug is easily seen.

DESCRIPTION OF THE EGG.

The egg is a small, glistening, opaque, somewhat "pear-shaped" body of a creamy white color. The size varies somewhat, but the average dimensions are about .643 mm. long by .289 mm. in diameter at the largest part. It consists of an outer, comparatively tough membrane, filled with an opaque, sticky fluid. The large end of the egg is placed toward the inner end of the cavity, while the small end is attached to the plug in the mouth of the cavity, which does not agree with the observations of Hinds and Turner (3) who describe the egg as having the "larger end outward as it rests in the grain." On the small end of the egg is a small protuberance that fits into the pit in the inner surface of the plug.

DESCRIPTION OF THE CAVITY.

The cavity is somewhat larger than the egg, there being an unoccupied space around the sides and bottom. The bottom is evenly rounded, the sides drawing gradually together at the mouth, the diameter of which is smaller than at any other part of the cavity. The mouth of the cavity being smaller than the larger end of the egg, it is necessary to enlarge the opening in order to remove the egg.

SIGNIFICANCE OF THE HABIT.

It is interesting to conjecture the uses of this careful and laborious method of oviposition. The point of prime importance is that the eggs are placed in such a position that the larvæ produced are surrounded by an abundance of food, and are in a position where they are protected during the helpless period of life. By being deposited beneath the surface of the corn, the eggs are protected to a large extent from external injury, from excessive drying, and from sudden changes in temperature. While serving to increase the protection from external injury, excessive drying, and change in temperature, the sealing of the cavity is undoubtedly useful as a protection against predaceous and parasitic enemies. Incidentally, this, probably, is quite effective as a protection to the eggs and larvæ against gases used in fumigation.

As a protection against natural enemies, the plug is no doubt serviceable, but it is not an absolute, and possibly not a very highly efficient safeguard, for, while making these observations, the writer noted numerous instances in which the predaceous mite, *Pediculoides ventricosus* Newport (2), successfully attacked and

destroyed the eggs and larvæ as well as the adult weevils. The method by which the mites gained access to the eggs was by burrowing between the plug and the surrounding corn, which, apparently, was not a difficult task.

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THE IRIDALES OF OHIO.

Lawrence W. Durrell.

Trees, herbs, and vines with sword-shaped or sometimes broad, netted veined leaves. Flowers bisporangiate or monosporangiate; usually showy though sometimes small and inconspicuous, with perianth often united; epigynous, pentacylcic, or reduced to tetracyclic or tricyclic; trimerous, usually actinomorphic; andrœcium in two cycles or either the inner or outer cycle wanting or vestigial. Ovulary trilocular; seeds with endosperm; fruit usually a capsule.

Synopsis of the Families and Genera.

I. Herbs with erect aerial stems and parallel veined usually narrow leaves; flowers bisporangiate.
  1. Stamens 6. Amaryllidaceae.
    (1.) Fruit a 3-valved loculicidal capsule; plant glabrous.
      a. Flowers in long spikes or racemes; perianth without a crown. *Manfreda* (*Agave.*)
      b. Flowers solitary or in umbels with a crown. *Narcissus.*
    (2.) Fruit indehiscent; plants villous. *Hypoxsis.*
  2. Stamens 3, alternate with the inner corolla segments. Iridaceae.
    (1). Style branches very broad and petal-like, opposite the stamens. *Iris.*
    (2.) Style branches not petal like, slender or filiform, alternate with the stamens.
      a. Stamen filaments not united.
        (a). Flowers not tubular, in terminal bracted clusters. *Gemmingia.*
        (b). Flowers single, perianth united in a long tube. *Crocus.*
      b. Stamen filaments united. *Sisyrinchium.*
II. Twining vines with netted-veined, petioled leaves, mostly cordate. Flowers diecious. Stamens 6. DIOSCOREACEAE. *Dioscorea.*

AMARYLLIDACEAE. Amaryllis Family.

Geophilous, perennial herbs with bulbs or rhizomes and scapose or aerial stems, or some tropical species trees. Leaves sword-shaped sometimes fleshy. Flowers bisporangiate, epigynous, pentacyclic, actinomorphoric, trimerous; ovulary trilocular; fruit usually a capsule.

Key.

1. Inflorescence a spike or raceme; plants glabrous. *Manfreda.*
1. Inflorescence umbellate or flowers solitary. 2.
2. Perianth tubular with a crown; plants glabrous, cultivated. *Narcissus.*
2. Perianth spreading, star-shaped, without a crown; plants villous. *Hypoxsis.*

Manfreda Salisb.

Fleshy herbs with bulbiferous rootstalks and bracted scapes, the leaves basal and the flowers in terminal spikes or racemes. Perianth tubular or funnelform withering persistent; sepals and petals of nearly equal length, united below into a tube. Stamens inserted on the perianth, exserted, filaments flattened. Ovulary trilocular, style slender, exserted; ovules numerous; capsule ovoid.

1. **Manfreda virginica** (L.) Salisb. False Aloe. Perennial geophilous herbs $\frac{1}{2}$ to 2 feet high; leaves sword-shaped, fleshy, with smooth or denticulate edges. Flowers borne in a loose spike on a scape 2 to 6 feet tall, greenish-yellow in color, solitary in the axils of bracts. Perianth nearly tubular, $\frac{2}{3}$ to 1 inch long. Capsule $\frac{1}{2}$ to $\frac{2}{3}$ inch diameter, slightly longer than thick. Lawrence county.

Narcissus L.

Bulbous herbs with leafless scapes and linear, basal leaves. Flowers solitary or several substended by a deciduous spathe; Perianth 6-parted bearing a cup-like crown in the throat. Stamens united with perianth tube. Ovulary trilocular, capsule thin-walled.

1. **Narcissus pseudo-narcissus.** L. Daffodil. Scape about 1 foot high; leaves linear; flowers bright yellow 2 to 3 inches broad, crown serrate. Cultivated.

Hypoxis. L.

Perennial, villous herbs with short rootstocks and grass-like leaves. Flowers borne on slender scapes, regular; stamens united with the bases of the perianth segments. Ovulary trilocular; capsule oblong, not dehiscent by valves.

1. **Hypoxis hirsuta** (L.) Coville. Yellow Stargrass. Leaves linear 5 to 12 inches long, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide. Flowers 1 to 6 umbellate, bright yellow within, greenish without, plant villous. General.

IRIDACEAE. Iris Family.

Perennial geophilous herbs with narrow two ranked leaves. Flowers mostly clustered, subtended by bracts, regular or irregular, bisporangiate epigynous, tetracyclic by reduction, trimerous. Ovulary trilocular and dehiscent.

Key.

1. Style branches very broad and petal-like, opposite the stamens; petals recurved. *Iris.*
1. Style branches not petal-like, slender or filiform; sepals widely spreading or erect. 2.
2. Flowers solitary; leaves with revolute margins. *Crocus.*
2. Flowers several on a long scape or leafy stem. 3.
3. Flowers crimson mottled; leaves sword-shaped. *Gemmingia.*
3. Flowers blue or white; leaves grass-like. *Sisyrinchium.*

Iris. (Tourn.) L.

Perennial herbs with horizontal, often woody or sometimes tuber-bearing rootstocks and erect stems with sword-shaped leaves. Flowers large, borne singly or panicled; sepals dilated or reflexed, style branches petal-like, arching over the stamens. Ovulary trilocular.

Key.

1. Stems tall; leaves glaucous; none of the perianth segments crested. *I. versicolor.*
1. Stems low; leaves not glaucous; outer perianth segments crested; perianth tube very slender. *I. cristata.*

1. **Iris versicolor** L. Large Blue-flag. Stems straight, 2 to 3 feet tall, often branched, leafy. Leaves erect, somewhat glaucous, 17 to 30 inches long, ¼ to 1 inch wide. Flowers several, violet blue, varigated with yellow, green and white; perianth segments glabrous and crestless. Capsule obscurely three-lobed. General.

2. **Iris cristata** Ait. Crested Dwarf Iris. Stems 1 to 3 inch high, leaves 4 to 12 inches long and $\frac{1}{3}$ to 1 inch wide. Flowers blue, sepals crested; perianth 1 to 1½ inches long. Capsule sharply triangular. Lawrence, Adams, Scioto, Pike, Ross, Jackson, Vinton, Hocking, Cuyahoga, Trumbull.

Gemmingia Fabr.

Erect perennial herbs with stout rootstocks and Iris-like leaves. Flowers in terminal clusters, purple mottled. Capsule figshaped.

1. **Gemmingia chinensis** (L.) Ktz. Blackberry-lily. Stem 1½ to 4 feet tall, leafy; leaves erect, sword-shaped, 8 to 14 inches long and ½ to 1 inch wide. Flowers several, 1½ to 2 inches long, perianth segments mottled with crimson and purple on the upper side, obtuse at the apex and narrow at the base, persistent and coiled together on the ovulary after flowering. From Asia. Escaped in Franklin county.

Crocus L.

Perennial tufted herbs, with narrow leaves arising directly from the corm; leaves with revolute margins; flowers solitary, perianth united in a long tube.

1. **Crocus vernus** All. Crocus. Leaves 2 to 4, equalling the flower, glaucous beneath; perianth segments 1 to 1½ inches long, lilac or white, often striped with purple, throat pubescent, not yellow. Escaped in Lake county.

Sisyrinchium L.

Perennial slender tufted herbs, with short rootstocks; stems simple or branched, two winged; leaves grass-like; flowers small, terminal umbellate, usually blue in color; capsule globose.

Key.

1. Stems simple with sessile terminal spathe; flowers with perianth ½ inch long; pedicles erect and shorter than the inner bracts; capsules pale. *S. angustifolium.*

1. Stems slender and ascending, mostly branched, broadly winged; flowers perianth less than ½ inch long on recurved pedicles. Capsules dark. *S. graminoides.*

1. **Sisyrinchium angustifolium** Mill. Pointed Blue-eyed-grass. Stem stiff, erect, pale and glaucous, winged, edges minutely serrulate, 4 inches to 2 feet high; leaves 4 to 9 inches long, 1–16 to ¼ inch broad, serrulate; spathes green or slightly purplish; flowers deep violet, blue, ½ inch long. General.

2. **Sisyrinchium graminoides** Bickn. Stout Blue-eyed-grass. Light green, somewhat glaucous; stems broadly winged, stout, erect or reclined, 8 to 18 inches tall; leaves 4 to 11 inches long and 1–12 to ¾ inch broad; umbels 2 to 4 flowered, pedicels thread-like; flowers ½ to ¾ inch broad, ¾ to 1 inch long, petals sparsely pubescent on the outer surafce. General.

Dioscoreaceae. Yam Family.

Slender twining vines slightly woody, with fleshy rootstocks; leaves petioled and netted-veined. Flowers diecious, epigynous and trimerous; ovulary trilocular.

Dioscorea (Plum.) L.

Slender twining vines with heart shaped or halbard-shaped leaves. Flowers inconspicuous and borne on pendulous spikes, panicles or racemes.

1. Leaves heart-shaped, abruptly acute or acuminate; without bulblets. *D. villosa.*

1. Leaves usually cuspidate and often halbard-shaped; with bulblets in the axils of the leaves. *D. bulbifera.*

1. **Dioscorea villosa** L. Wild Yam. Stems slender and twining, 6 to 15 feet long; rootstocks slender, horizontal, woody; leaves heart-shaped, 9 to 13 nerved, acuminate at the apex, thin green, glabrous on top, sometimes pubescent beneath, 2 to 6 inches long, 1 to 4 inches wide, petioled; petiole often longer than the blade. Flowers greenish-yellow, the staminate 1–16 to $\frac{1}{8}$ inch long in drooping panicles 3 to 6 inches long; the carpellate 3–16 inch long in drooping racemes. Capsules membranous, strongly 3 winged. General.

2. **Dioscorea bulbifera** L. Air Potato. Twining vines; leaves about 2 inches long and 2 to 3 inches broad, petioled, the petiole longer than the blade, halbard-shaped, acuminate at the apex, thin, green, 9-nerved. Flowers greenish, in loose axillary racemes. Tubers in the axils of the leaves. Tropical Asia. Escaped from gardens in Madison county.

MEETINGS OF THE BIOLOGICAL CLUB.

ORTON HALL, January 12, 1914.

The meeting was called to order by the President at 7:30 and the minutes were read and approved. The following were elected to membership: Norman Sherer, Floyd De Lashmut, Clayton Long, Maxwell Scarff, Margurite Iekes, Francis E. Piper, Harold Peebles and Christian R. Gaiser.

The first paper of the evening was by Prof. Durrant, on the Biology of the Guinea Pig. Prof. Durrant kept Prof. Barrows' Guinea pigs during the summer when the observations presented were made. The Guinea pig belongs to the order of Rodentia, to which order also belongs the water-pig of South America, which sometimes reaches a length of five or six feet and a height of eighteen or twenty inches. The Guinea pig is very prolific, the period of gestation being 66 or 67 days. The time of mating after birth is from five days to several weeks. The female is from 42 to 62 days old at the time of mating. As to the number of young in a litter, Prof. Durrant made several observations of which the following are the results:

Four litters of two each, twelve litters of three each, three litters of four each.

There is a great variation in the size of the young, but no relation between the size and the number in the litter.

In one case he had a rough coat female crossed with a white male, which produced a white, red and black offspring. The same parents at a later time had a yellow rough coat young one.

The next paper on the program was a review of Herrick's paper, "The Origin and Evolution of the Cortex," by Miss Ickes. Instincts are present because the tracts have been inherited; a dilema is the cause of consciousness. Consciousness is not a simple element, but is a cirucit. One of the basic paths into the cortex is from the thalamus and the thalamus is already complex. The physical state has much to do with the path that the impulse takes. A lower form must depend on its reflexes, while a higher form may determine the solution of its difficulties by means of its cortex.

The rest of the evening was given over to the discussion of the meetings at Atlanta and Philadelphia. Prof. Osborn reported on the zool gical meeting at Atlanta. There was a discussion on the teaching of sex hygiene and another as to whether it was not of more importance to teach life actions rather than morphology in the first year course of zoology.

Professor Griggs gave a report of the papers read before the botanical society. Professor Barrows reported a good attendance at Philadelphia and especially mentioned Riddle's work on the control of sex in pigeons.

Professor Barrows reported that he had two tailless cats from which he is trying to breed a race of tailless animals. Mr. King reported on some tree-hoppers which hibernate on peach twigs. Mr. Shadle reported that a fish-hawk had been taken at Lockbourne. Professor Griggs tcld of a collection of trees of Georgia that he saw while at Atlanta.

Blanche McAvoy, *Secretary.*

Date of Publication, May 21, 1914.

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DIPTERA OF MIDDLE AMERICA.

FAMILY SYRPHIDÆ.

JAS. S. HINE.

A large number of species of diptera from southern localities have accumulated in the collections at the Ohio State University. They have been procured from various sources and come from many localities, having been taken by different collectors. In working up this material it is my purpose to consider one family at a time. Having quite fully studied the Syrphidæ I offer for publication the following notations on the included species. For the purposes of this paper and those of the same series to follow the term "Middle America" may be taken to include a wide stretch of territory from Southern United States to points in South America several degrees beyond the Equator.

MICRODON Meigen.

Microdon angustus Macquart. This name is applied to two specimens from Bartica, British Guiana. The body is elongate, face, legs, scutellum and base of abdomen pale yellowish; disk of thorax greenish black with a transverse narrow golden band; toward the apex the abdomen gradually shades into brown; antennæ long, scutellum with spines. Total length 14 mm. Microdon angustiventris Macquart must be very close to this species.

Microdon baliopterus Loew. One specimen from Gualan, Guatemala, January 20th, 1905.

Microdon bidens Fabr. Thorax greenish black, scutellum with the extreme apex and two spines pale brown. Abdomen and legs mostly reddish. Wings uniformly fumose. Five specimens from Bartica, British Guiana, April and May.

Microdon coarctatus Loew. A small bright green species with many of the wing veins margined with dark brown. Three specimens from Louisiana.

Microdon flavitibia Walker. Thorax and abdomen purplish black. Wings fumose. Of the same form and size as bidens. Six specimens from Bartica, British Guiana.

Microdon rufiventris Rondani. Face, front and thorax shining green clothed with golden pile; antennae brown; abdomen reddish yellow with the exception of a triangular green spot near the scutellum. Legs pale, wings nearly hyaline. Length 11 mm. One specimen from Bartica, British Guiana.

Mixogaster Macquart.

Five American species have been described in this genus. Some of them might well be placed in Microdon were it not for the discinctly clavate abdomen but others do not show such close relationship with that genus. M. breviventris Kahl is the only species that has been taken as far north as the United States. An additional species was taken at Los Amates, Guatemala, and is here described as new. The following key for the separation of the known species has been compiled in large measure from descriptions and figures that have appeared in various publications.

1. Thorax with a middorsal yellow stripe. *conopsoides Macq.*
   Thorax not with a middorsal yellow stripe. 2.
2. The third longitudinal vein emits a stump into the first posterior cell. 3.
   The third longitudinal vein does not emit a stump into the first posterior cell. 4.
3. Wing clear hyaline, legs brown. *claripennis n. sp.*
   Base of marginal cell and a cloud along the third vein brown, bases of all the tibiæ light yellow. *bellula Will.*
4. The vein closing the distal end of the first posterior cell almost straight. *breviventris Kahl.*
   The vein closing the distal end of the first posterior cell distinctly angulated. 5.
5. Face extraordinarily arcuate. *dimidiata G. Tos.*
   Face normal. *mexicana Macq.*

Mixogaster claripennis n. sp. Length about 10 mm., body black with yellow bands, legs generally brownish. Face yellow on each side and black at middle, clothed with yellow appressed hairs, cheeks black; front largely shining black narrowed near lower third where there is a transverse space clothed with short yellow hairs, vertex tumid, also a prominence just above base of antennæ. Antennæ long, first segment long and slender, second segment short, third segment thickened and about as long as the first, whole antenna black except the extreme base of first segment which is yellow. Thorax black in ground color, humerus with a very small pale spot, suture with a very narrow band of yellow pile. Scutellum golden pilose. Wings clear hyaline.

Legs brown, coxæ and parts of the femora darker, bases of the tibiæ somewhat paler. Abdomen generally black, second segment narrow and elongate, on basal half with two transparent spots separated by a black interval, apex of the same segment with a narrow pale band, apex of the third segment with a narrow band of golden yellow pile, apex of the fourth segment and all of the fifth brownish. A male type taken at Los Amates, Guatemala, in February, 1905.

This species is related to Willistons' bellula but differs from it in having entirely hyaline wings, and the coloration of the legs and abdomen is quite different. Also the elongation of the stump of a vein from the third longitudinal almost dividing the first posterior cell appears to be an important characteristic of claripennis.

Baccha Fabricius.

Baccha callida n. sp. Length about 10 mm. Front with a slight prominence for the insertion of the anennæ, front, face and antennæ yellow, a small geminate black spot on the middle of the front near the antennæ. Thorax largely yellow with four black stripes separated by yellow on the dorsum, and an irregular greenish brown marking passes beneath the scutellum to the bases of the middle legs; wings narrowly at base and along the anterior border pale yellowish, otherwise clear hyaline; legs all yellow with the exception of the hind pair, each of which have a pale brown band around the apical third of the femur and a wider band of the same color on the basal half of the tibia. Abdomen black, brown and yellow, first segment yellow with a black marking beneath the scutellum and a clear brown band on the posterior margin, second segment brown on anterior half, this followed by an area of yellowish somewhat intermixed with brown and this by a black band occupying more than the apical fourth of the segment, third segment with a middorsal stripe slightly abbreviated before, an apical band and an oblique marking on each side connected with apical band black, fourth segment like the third, fifth segment with three black stripes, all the segments behind the second are yellowish where they are not black.

The male type collected at Puerto Barrios, Guatemala, March 5, 1905.

This species is somewhat suggestive of lineata but is colored quite differently.

Baccha capitata Loew. A female example of this fine species was taken at Holguin, Cuba, by H. S. Parish. The species has been reported from Cuba and Porto Rico by previous writers. Loew's type is a male. From reading the original description and comparing my specimen with it I find the two sexes are very similar in coloration.

Baccha conjuncta Wiedemann. Two female specimens of this species were taken at Bartica, British Guiana. The head is short and the antennæ are attached high up and much elongated for a species of Baccha. The front is wide with the sides parallel giving quite a different appearance from that present in many species where the front is distinctly narrowed above. The two specimens differ in having the submarginal cell hyaline in one and plainly yellowish in the other.

Baccha cultrata Austin. A female specimen from Puerto Barrios, Guatemala, agrees well with Austin's figure and description in the Proceedings of the Zoological Society of London for 1893, page 151. Austin's specimens were taken in Brazil and this record extends the range for the species much to the northward and establishes it as a member of the North American fauna. The general form is quite different from most species of Baccha, but the characters of the head are nearly normal.

Baccha clavata Fabricious. Specimens of this common species are before me from many localities ranging from South America to Wisconsin. I have taken it plentifully in Ohio, Louisiana and in several localities in Guatemala and Honduras where it occurs from the Atlantic to the Pacific.

Baccha lineata Macquart. This is a very common species in Guatemala and numerous specimens are at hand from Honduras and British Guiana. The coloration of the body and wings varies somewhat in a series of specimens. Williston suggests that livida Schiner may be the same as lineata Macquart and from my study of more than a score of specimens of both sexes I am convinced that the species should be called lineata and that livida should drop into synonomy. Macquart describes and figures the female and my specimens of that sex are as near to the figure certainly as most identifications are to his reproductions.

Ocyptamus Macquart.

Ocyptamus dimidiatus Fabricius. Plentiful in a number of localities in Guatemala and Honduras.

Ocyptamus funebris Macquart. Three specimens. A male from Puerto Barrios, Guatemala, March 5th, and a male and female from San Pedro, Honduras, February 21, 1905.

Ocyptamus fuscipennis Say. Numerous specimens from Slidell, Louisiana. The species is common in all parts of Ohio.

Ocyptamus scutellatus Loew. Four specimens from Boniato, Cuba. It is much like dimidiatus but the wings are more suffused and the body is not so highly colored.

Salpingogaster Schiner.

Salpingogaster pygophora Schiner. A male specimen from Boniato, Cuba, appears to be this species. The mesonotum is dark, scutellum light, slightly darkened across the disk, legs wholly yellow and abdomen reddish-brown throughout.

Melanostoma Schiner.

Melanostoma fenestratum Macquart. Three specimens from La Paz, Bolivia.

Syrphus Fabricius.

Syrphus bisinuatus Williston. Taken at Laguna, Guatemala.

Syrphus poecilogaster Philippi. From Arequipa, Peru; La Paz, Bolivia and from Valparaiso, Chile.

Syrphus similis Blanchard. From Santiago, Chile. This species is very similar to S. ribesii, but the markings are paler and the wings are slightly fumose.

Mesogramma Loew.

Mesogramma basilaris Wiedemann. From Puerto Barrios and Los Annates, Guatemala and Boniato, Cuba.

Mesogramma bidentata Giglio-Tos. From Puerto Barrios, Los Amates and Santa Lucia, Guatemala.

Mesogramma ciliata Gigilo-Tos. From Los Amates, Guatemala.

Mesogramma confusa Schiner. From Los Amates, Guatemala.

Mesogramma diversa Giglio-Tos. From Los Amates, Guatemala.

Mesogramma duplicata Wiedemann. From Puerto Barrios and Los Amates, Guatemala.

Mesogramma laciniosa Loew. From Gualan and Los Amates, Guatemala; San Pedro, Hondurus, and Holguin and Bonioto, Cuba.

Mesogramma linearis van der Wulp. From Los Amates, Guatemala and Boniato, Cuba.

Mesogramma marginata Say. From Los Amates, Guatemala and Slidell, Louisana.

Mesogramma polita Say. From Panzos, Gualan, and Puerto Barrios, Guatemala.

Mesogramma rombica Giglio-Tos. From Los Amates, Guatemala and Boniato, Cuba.

Mesogramma saphridiceps Bigot. From Georgetown, British Guiana.

Mesogramma subannulata Loew. From Boniato, Cuba and Los Amates and Puerto Barrios, Guatemala.

Mesogramma variabilis van der Wulp. From Los Amates and Santa Lucia, Guatemala.

Sphærophoria St. Fargeau and Serville.

Sphœrophoria picticauda Bigot. Numerous specimens from Los Amates, Guatemala and from San Pedro, Honduras. The San Pedro specimens were collected by E. B. Williamson.

VOLUCELLA Geoffroy.

Volucella abdominalis Wiedemann. Three specimens of this conspicuous species have been received from Cuba, a female from Holguin and a pair from Boniato. The large size, the uniform blue-black abdomen, yellow scutellum and face and plain black cheeks characterize it. Length 16 mm.

Volucella azurea Philippi. A brilliant green species, wings clear hyaline with a conspicuous dark spot at the stigma. Length 13 mm. One female from Santiago, Chile.

Volucella boliviana n. sp. Body dark colored, front and face prominent making the head appear unusually large, wings hyaline. Length 12 mm. Front and face wide, pale yellowish green; front tumid, antennæ rather small, reddish; face concave beneath the antennæ, quite prominent above the oral margin; eyes pilose, pilosity of the face and front largely dark colored. Thorax, dark, scutellum paler, legs black with the exception of the bases of all the tibiæ which are red, wings hyaline. Abdomen dark with mostly dark hair, some tufts of white hair on the outer margins of each segment behind the incisures.

Type female from La Paz, Bolivia. Also a female from Arequipa, Peru.

At first glance this species much resembles a Goniops of the family Tachinidae, but it has all the structure characters of Volucella.

Volucella dichroica Giglio-Tos. Entirely purplish-green with unevenly infuscated wings. Length close to 10 mm. A male from Los Amates, Guatemala.

Volucella esuriens Fabricius. A large violet colored species with the base of the wing distinctly brown before. The species is widely distributed and has many synonyms. Length 16 mm. Taken at Santa Lucia, Guatemala.

Volucella eugenia Williston. A specimen from Boniato, Cuba seems to be this species. Face and front pale, cheeks black, thorax dark on the disk, sides and scutellum pale. A row of prescutellar bristles and another row at the apex of the scutellum. Wings nearly hyaline, crossveins narrowly margined with fuscus. Legs dark, tibiæ partially pale. Abdomen black with yellow on sides of first and second segments. Length 13 mm.

I have made this identification with some hesitation mainly on account of the yellow at base of abdomen which Williston does not mention in his description.

Volucella guianica n. sp. Length 7 mm., entire body shining dark green, antennæ and face, including the cheeks, yellow, wings with dark markings.

Face strongly produced forward and downward, tubercle prominent, front brown below, black at vertex. Thorax including scutellum dark green, a row of spines at the apex of the scutellum

and one before the scutellum; wing largely hyaline and brown, base largely hyaline, anterior border pale yellowish, first basal cell with a small oblique dark marking; a large dark marking at stigma sending out three prominent extensions, one backward along the veins which close the second basal and anal cells, another obliquely along the vein which separates the second and third posterior cells and one outward along the costa. The first second and third posterior cells also have more or less dark color at their apexes. Legs dark with the exception of the apical two-thirds of each front femur and all the tarsi which are pale. Abdomen very dark shining green. Type female from Bartica, British Guiana, collected by H. S. Parish.

Volucella macula Wiedemann. General color metallic reddish, wings nearly hyaline with a well defined quadrate black spot near the middle of the costal border. Length 9 mm. Four specimens from Bartica, British Guiana.

Volucella obesa Fabricus. This is the most common species of the genus in middle America. Body shining green, wings nearly hyaline with a black stigmatic spot and a black point at the apex of the marginal cell. Length 12 mm. one specimen a little smaller. Our collection contains specimens from Mexico, Cuba, Guatemala, Honduras, British Guiana and Bolivia.

Volucella perlata n. sp. Face and front bright shining green. Thorax bright green, scutellum and abdomen pale with shining irridescent reflections, wings yellowish, more intense on apical half. Length 9 mm.

Face produced largely downward, green, and obscure yellow markings on the cheek, antenna including the arista yellow, eyes hairy. Thorax green, scutellum pale with an apical depression, three weak bristles on each side; legs dark with purplish or greenish reflections, knees pale; wings yellowish, most intense in the marginal and first second and third posterior cells. Abdomen pale with a very bright, shining irridescent reflection. Type male taken at Los Amates, Guatemala.

Volucella picta Wiedemann. Very close to fasciata and pusilla from the United States. In fact Williston suggests that the latter may be a synonym of picta. Length 8 mm. Specimens from Gualan, Guatemala. The larva probably lives in the stems of some species of cactus.

Volucella praescutellaris Williston. A modest colored species. Dorsum of thorax green with yellow and black pile intermixed, scutellum pale, a row of prescutellar bristles and eight rather strong bristles on the posterior border of the scutellum; wings infuscated, not quite so dark on posterior border; legs black; abdomen yellow and brown, the tip shining. Length between 11 and 12 mm. A male specimen from Los Amates, Guatemala.

Volucella scutellata Bigot. Mostly plain black, front and face pale, scutellum brown with stout spiniferous tubercles. Many of the veins adjacent to the costal border of the basal part of the wing margined with brown. Length 15 mm. Santiago, Quillota and various other localities in Chile.

Volucella tympanitis Fabricus. A rather small pale species with the abdomen banded with brown. Wing hyaline with a brown spot at stigma and another near the apex. **Volucella ardua** Wiedemann seems to be a synonym. True Wiedemann recognizes both as valid species in the same publication but the descriptions read so near alike that I cannot make the distinction. Length 9 mm. A specimen from Bartica, British Guiana and one from Santa Lucia, Guatemala.

Phalacromyia Rondani.

Phalacromyia nigrifrons n. sp. A small dark colored species. Thorax, including the scutellum, shining purple, abdomen brown, front black, face yellow. Length 6 mm.

Face much produced forward but not so much downward, yellow without black markings, antenna yellow, proboscis near the length of the front femora; front shining black, the color changing at the insertion of the antennæ producing a pronounced contrast with the yellow of the face. Thorax shining purple, scutellum of the same color as the thorax and with a distinct impression just before its apex. Legs all dark brown with the exception of the posterior tibiæ which are pale. Wings very pale yellowish, costal border more intense, a dark brown point at stigma. Abdomen dark yellowish brown, slightly darker at the incisures.

The type female taken at Bartica, British Guiana, May 28, 1901, by H. S. Parish.

Phalacromyia virescens Williston. A pale green species with yellowish wings. Anterior part of the thorax yellowish, a small dark spot in front of the scutellum and another in the transverse impression just before its apex. Front pale green, face yellow. A female specimen from Bella Vista Yungas, Bolivia.

The locality is some distance from where Williston's type was procured but the specimen answers the description in detail.

Eristalis Latreille.

Eristalis aemulus Williston. Five specimens from Bartica, British Guiana. Williston has reported the species from Mexico and Central America.

Eristalis albifrons Wiedemann. We have the species from Louisana, Yucatan and Guatemala.

Eristalis assimilis Macquart. Numerous examples of both sexes from Arequipa and Puno, Peru.

Eristalis atrimanus Loew. Specimens from Cuba are considered as this species. This and Wiedemann's fasciatus must be much alike.

Eristalis bogotensis Macquart. From La Paz, Bolivia and Puno, Peru.

Eristalis conicus Fabricus. Numerous specimens from Bartica, British Guiana and one which is typical for the species from Livingston, Guatemala. This is the first North American record so far as I can find.

Eristalis cubensis Macquart. So far as I am aware this species has not been recognized since Macquart named it, but there are nearly fifty specimens in our collection from various places in Louisiana and Guatemala and one each from Honduras and Jamaica agreeing well with its description. C. W. Johnson says he has the same from Cuba, the type locality, and my opinion is that Williston referred to the same under "21", Biologia Vol. III, page 65.

The species is much like alibifrons but the markings of the abdomen are distinctly yellower and the pile of the front is mostly black instead of pale.

Eristalis fasciatus Wiedemann. Numerous specimens from Bartica, British Guiana.

Eristalis furcatus Wiedemann. Specimens from various places in Guatemala. Common on the west shore of Lake Amatitlan in low ground February 7th.

Eristalis minutalis Williston. A single example from San Pedro, Honduras, February 25, 1905. Collected by E. B. Williamson.

Eristalis obsoletus Wiedemann. Taken at several stations in Guatemala during the first part of February.

Eristalis philippi Schiner. Three specimens from Chile. The type came from Chile.

Eristalis pusillus Macquart. Said to be the same as **Eristalis tricolor** of Jaennicke. From several places in Guatemala.

Eristalis ruficeps Macquart. A specimen from Coroico Yungas, Bolivia has many characters with ruficeps although it may not be that species.

Eristalis rufiventris Macquart. Rather common, flying near the margin of a stagnant pond at Los Amates, Guatemala, January 18, 1905. Other specimens from San Pedro, Honduras.

Eristalis scutellaris Fabricius. From Los Amates, Sanarate and Puerto Barrios, Guatemala and from Bartica, British Guiana, more than a dozen specimens.

Eristalis triangularis Giglio-Tos. Collected at Los Amates, Gualan, Mazatenango and Santa Lucia, Guatemala. Others have taken the species at several stations in Mexico and Brazil.

Eristalis vinetorum Fabricius. Widely distributed and common from southern United States southward. Lynch reports it from Argentina and Macquart claimed to have it from Philadelphia. We have abundance of specimens from Cuba, Guatemala, British Guiana and Louisiana.

Lycastrirhyncha Bigot.

Lycastrirhyncha nitens Bigot. One specimen of this extraordinary species taken at Los Amates, Guatemala near the middle of January 1905.

Meromacrus Rondoni.

Meromacrus acutus Fabricius. One specimen from Los Amates, Guatemala. The front margins of the wings are widely infuscated.

Dolichogyna Macquart.

A genus somewhat related to Helophilus. The latter genus is listed from South America but all my specimens belong to Dolichogyna on account of the wide and prominent front, and the exserted sexual organ of the male. There may be some question whether or not it is advisable to separate the two genera on such small characters. I have four species which is more than is recognized usually, but surely the four are congeneric. The bibliography of the species of the genus is given by Williston in Transactions of the American Entomological Society, Vol. XIII, page 320 and Vol. XV, page 392.

KEY TO THE SPECIES.

1. Specimens 10-12 mm. in length. 2.
   Specimens less than 9 mm. in length. *abrupta n. sp.*
2. Legs largely black, face much produced. *nigripes Bigot.*
   Legs largely yellow, face not so much produced. 3.
3. Markings of the abdomen bright yellow, at most only a trace of pale color near the middorsal line. Legs all yellow. *fasciata Macquart.*
   Markings of the abdomen largely pale gray. Legs often partially black, variable. *chilensis Guerin.*

Dolichogyna abrupta n. sp. Small sized species, markings of the abdomen mostly bright yellow. Length a little less than 9 mm.

Male. Ocelli widely separated and located within a black area at vertex, all the front except the vertex, yellow, a crescent shaped area immediately above the antennæ devoid of pile, from thence to where the black ground color begins with prominent dark pile; the black vertex and rear of the head with yellow pile. Front prominent with the antennæ inserted on the most prominent part. Face yellow, mostly naked, cheeks slightly brown on posterior margin. Dorsum of the thorax dark and clothed with yellow pile; margins next the insertions of the wings, two stripes near the mid-dorsal line and scutellum yellow; wings hyaline; legs mostly reddish yellow, some or all of the femora black or blackish on basal parts. Abdomen dark above, second

segment with a large yellow triangular marking on each side, third with a similar shaped marking which is yellow outwardly and gray inwardly, fourth with a similar shaped marking which is nearly all gray; venter mostly pale. Hypopygium exserted and protruding forward under the abdomen to about the middle of the third segment.

Female. Like the male but the markings of the dorsum of the abdomen are more plainly yellow.

Type male, alotype female and four paratype males from Arequipa, Peru, October 28, 1898.

Dolichogyna chilensis Guerin. This species was described as Helophilus but if I have made a correct determination it should be placed in this genus. Helophilus pictus Philippi I consider a probable synonym. Nearly a dozen specimens from Arequipa and Puno, Peru, have been placed here.

Dolichogyna fasciata Macquart. Helophilus chilensis Walker and Dolichogyna hahni Bigot have been placed as synonyms by Williston. This is the type of the genus. Five specimens from Santiago, Valparaiso and Chiloe, Chile, are determined as fasciata. The markings of the abdomen are mostly bright yellow and nearly the whole body is clothed with prominent yellow pile.

Dolichogyna nigripes Bigot. A male specimen with the face produced and legs mostly black is placed here. The middle and front tarsi are flattened and the corners at the apex of each segment are produced into rather long appendages thus forming a pronounced type of foot very different from that present in the other species. The knees, bases of all the tibiæ and all the tarsi are yellowish while the other parts of the legs are shining black. One specimen from Puno, Peru.

Asemosyophus Bigot.

Asemosyophus bicolor Bigot. Two specimens taken at Lake Amatitlan February 7, 1905.

Asemosyophus mexicanus Macq. Two males and a female from San Antonia Canyon, California, July 25, 1907.

Xylota Meigen.

Xylota chloropyga Schiner. A specimen from Bartica, British Guiana.

Xylota cœrulea Rondani. Same as Strephus antennalis Philippi. One specimen from Alhue, Chile.

Stilbosoma Philippi.

Stilbosoma cyanea Philippi. This shining green species with red front and face and black antennæ is one of the most striking spryphides I have seen. Three specimens from Santiago and Quillota, Chile.

Ceria Fabricius.

Ceria tricolor Loew. Two specimens from Holguin, Cuba, collected by H. S. Parish, December 23, 1904.

MIDDLE MISSISSIPPIAN UNCONFORMITIES AND CONGLOMERATES IN NORTHERN OHIO.

By G. F. Lamb.

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In northern Ohio there are two unconformities with a conglomerate associated with each which occur in rock of about middle Mississipian age. The area in which the unconformities and conglomerates have been observed include portions of five contiguous quadrangles—West Salem, Wooster, Massillon, Medina and Akron.

Two conglomerate beds have long been known in central Ohio and which Herrick recognized as extending northward into this part of the state. His conclusion would appear to be correct, but it is not yet known that these beds at the north lie at exactly the same horizon as those in central Ohio.

In his report on Wayne county (Ohio Geol. Surv. Vol. III, p. 539) Read incidentally mentions a stratum filled with quartz pebbles which he observed in a quarry at Wooster. In the summer of 1912, the writer examined this outcrop and noted the presence of the unconformity. Later study at other points led to the discovery of another unconformity at the base of the lower conglomerate. The presence of these stratigraphic breaks is evidence of crustal movement in this region in middle Mississippian time that may have involved a larger area than is at present known.

The principal facts may be noted briefly: *The lower conglomerate.* The best exposures of the base of this stratum occur on either side of the Killbuck Valley in the western part of the Wooster and eastern part of the West Salem quadrangles. The conglomerate varies in thickness from about two feet to eighteen or twenty feet as found along the Killbuck, but thickens eastward and is thirty to forty-five feet before it passes under cover. The basal one to three feet is virtually a bed of loosely cemented quartz pebbles ranging in size from shot to nearly an inch in diameter. They are usually $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, well rounded, and quite even in size at any given place. Cobble stones from hard layers of the underlying shale are frequent and often lenticular in shape, ranging in size from two to six inches. The largest one found measured two and one-half feet long by one and one-half feet wide, and over five inches thick, and completely embedded in quartz pebbles.

At every point where the base was well exposed, the pebble and cobble bed rests upon blue shale with the contact sharp and generally with very conspicuous undulations. The remainder

of the conglomerate stratum is largely a coarse grained standstone with streaks of fine pebbles. This is followed by shale and fine grained clayey sandstone up to the next unconformity.

The lower conglomerate three miles east of Wooster lies about six hundred and twenty feet above the Berea sandstone and about two hundred feet below the lowest Coal Measure rock in the same locality. These figures would appear to put the time of these movements in the late Mississippian, but this system of rocks is known to have been deeply eroded in this region in Mississippian time. To double or treble the two hundred feet would seem quite permissible, and it may have been much more. For the above reasons, the time of the movements is assigned to middle Mississippian.

At Berea, Ohio, the top of the Berea Sandstone lies at 760 feet above sea, 42 miles due south at Apple Creek Village in the southern part of the Wooster quadrangle, it lies at 300 feet above, dipping 11 feet per mile. The dip of the lower conglomerate in the same direction, is almost exactly the same. This would indicate not merely a local uplift, but an uplift of considerable extent so far as a north-south direction is concerned. There is reason to think it extended much farther southward.

The upper conglomerate. This bed lies, as found so far, from 45 to 85 feet above the base of the lower conglomerate. The lesser measurement applies in the southern part of Wooster quadrangle, and the interval increases northward. The dip of this stratum southward is 13 feet to the mile and lies nearly horizontally from east to west. It is apparent that it departs somewhat from a parallel to the lower conglomerate and the Berea due to differential movement. It is a remarkably uniform stratum in thickness, in composition, and in uniformity of size of pebbles. From east to west it has been observed across nearly its entire belt of outcrop, and about twenty-five miles along the belt. It is only one to three feet in thickness, is always largely and often purely a bed of quartz pebbles ranging in size from shot to pebbles three-fourths of an inch in diameter and notably even in size at any one point. Cobblestones from under rock three to five inches in diameter are found in places. Overlying the pebble bed occurs rather soft, fine grained clayey sandstone and shale, typical of the Logan shale to the southward, and carrying the same fauna.

It was marine laid as shown by brachiopods and crinoid fragments. These occur mingled with the pebbles. The persistency of the bed, the uniformity of its thickness, the assortment of its pebbles, and their well rounded form, the writer ascribes to the work of waves in a sea slowly advancing upon the land. The character of the lower conglomerate indicates that it was laid down in the same way. Both appear to be basal conglomerates.

Where was the land from which these pebbles came? One would be inclined to answer at once, from the west and north where older rocks now occur. But this leaves a structural feature observed in both conglomerates rather hard to explain. At different points south-east of Wooster, the upper conglomerate is found to be cross bedded with bedding planes dipping sharply toward the north. In the northwestern part of the Massillon, the southwestern part of the Akron, and the eastern part of the Medina quadrangles, the lower conglomerate shows conspicuous crossbedding, either toward the west or toward the north. It is hard to see how this structure can occur in any other way than dipping away from a shore, whether produced by stream current or undertow from waves. If one would assign the structure in this case to northward flowing currents along shore, another difficulty is met. In the last named region where twenty to thirty feet of the conglomerate is exposed in one outcrop, various levels of crossbedding occur in different directions varying from west to north. This would seem to be more like a delta deposit of a stream flowing from the southeast. No case of crossbedding has been found which would indicate that the shore was to the west or north, but rather to the south and east. If the interpretation of this structure be correct, it points to the presence of a land mass where we have thought there was open sea.

The existence of these unconformities in middle Mississippian rock would seem to throw light on the time of the very numerous small folds found in the Medina quadrangle and only less numerous in a number of other quadrangles eastward to the Pennsylvania state line. They rarely occur where the Pennsylvanian is exposed above, hence the uncertainty of assigning them to that age or later. Some of them very likely belong to post Mississippian time, but it should be stated that so far as observed they are much less numerous in the Pennsylvanian than in the Mississippian and particularly in the Mississippian below the conglomerate horizons. One very clear case occurs in an outcrop in the north-east corner of the Medina quadrangle in a ravine one-half mile southwest of Hinckley village, where the horizontal beds of the Sharon conglomerate (base of Pennsylvanian) rest upon the upturned edges of the Mississippian. The top of the latter here is about 430 feet above top of the Berea, or more than 150 feet below the horizon of the lower conglomerate. The contact is sharp and the layers of shale are inclined about twenty-five degrees.

If these conglomerates described above are the same beds found in the central part of the state and southward, which would appear to be true, it implies the presence of associated unconformities wherever they occur.

THE PANICUMS OF OHIO.

Blanche McAvoy.

This study of the Panicums of the state and the distribution as given for each species are based on specimens in the state herbarium at the Ohio State University. All of the Panicums in the herbarium were studied and their identification revised by Hitchcock and Chase of the United States Department of Agriculture, while they were preparing their material for "The North American Species of Panicum." It was thought advisable not to include any records of plants not so identified as it is sometimes difficult to discover the exact species from the older names used a few years ago.

Panicum L.

Perennial or annual grasses; inflorescence usually a panicle, rarely a raceme; spikelet two-flowered, but the upper flower either staminate, sterile or reduced; the empty glumes unequal, the outermost one often minute; lemma and palet of the perfect flower indurated; margin of the lemma inrolled; grain freely inclosed within the flowering glumes.

Key.

1. Basal leaves like those of the stem. 2.
1. Basal leaves unlike those of the stem. 10.
2. Basal leaf-sheaths compressed, often keeled. 3. (Agrostia).
2. Basal leaf-sheaths round, little flattened, never keeled. 4.
3. Fruit stipitate. *Panicum stipitatum*. (2).
3. Fruit not stipitate. *Panicum agrostoides*. (1).
4. Leaf-sheaths smooth, panicle smooth; tall perennials having long rootstocks or stolons with numerous, small, broad, scale-leaves. *Panicum virgatum*. (3).
4. Leaf-sheaths pubescent, or if smooth, then the branches of the panicle pubescent; annuals. 5.
5. Leaf-sheaths smooth, panicle branches rough pubescent. *Panicum dichotomiflorum*. (4).
5. Leaf-sheaths pubescent. 6.
6. Spikelets ovate, more than 1/8 inch long, spikelets close. *Panicum miliacium*.
6. Spikelets lanceolate or elliptic, less than 1/8 inch long; spikelets distant. 7.
7. Panicle narrow, branches of the panicle ascending; spikelet less than 1/8 inch long. *Panicum flexile*. (8).
7. Panicle spreading when mature; spikelet $\frac{1}{16}$ inch or less long. 8.
8. Panicle very large, usually 1/2 the plant. *Panicum capullare*. (6.)
8. Panicle not so large, usually $\frac{1}{3}$ of the plant. 9.
9. Stem delicate; leaf blade less than 1/4 inch wide. *Panicum philadelphicum*. 9.
9. Stem stout; leaf-blade usually 1/4 to 3/8 inch wide. *Panicum gattingeri*. (7).
10. Leaf-blades 1/2 way up the stem less than 1/2 inch wide, attenuate to cordate at the base. 11.
10. Leaf-blades 1/2 way up the stem 1/2 inch or more wide, usually cordate to clasping at the base. 30.

11. Spikelets $\frac{1}{8}$ inch long or more. 12.

11. Spikelets less than $\frac{1}{8}$ inch long, usually about $\frac{1}{16}$ inch. 22.

12. Leaves less than $\frac{3}{16}$ inch wide and about 18 times as long as wide. *Panicum depauperatum.* (10).

12. Leaves more than $\frac{1}{4}$ inch wide, and not elongated. 13.

13. Upper surface of the leaves glabrous. 14.

13. Upper surface of the leaves pubescent. *Panicum leibergii.* (24).

14. Outer empty glume $\frac{1}{3}$ as long as the spikelet, short acute. *Panicum scribnerianum.* (25).

14. Outer empty glume $\frac{1}{2}$ as long as the spikelet, long acuminate. *Panicum xanthophysum.* (26).

15. Stem simple or with basal branches only. 16.

15. Stem at length faciately branched. 22.

16. Hairs on the leaf sheath almost an $\frac{1}{8}$ inch long or longer, spreading, usually dense. *Panicum linearifolium.* (11).

16. No hairs on the leaf sheath, or with hairs less than $\frac{1}{16}$ inch long, sometimes ciliate on the margin. 17.

17. Leaf blade $\frac{3}{16}$ inch or less wide, usually 18 or more times as long as wide; spikelets usually glabrous. 18.

17. Leaf-blade usually much more than $\frac{1}{4}$ inch wide, never more than 8 times longer than wide; spikelets more or less pubescent. 20.

18. Leaves much elongated; often 6 to 10 inches long, attenuate at the base. *Panicum werneri.* (12).

18. Leaves not elongated; generally less than $3\frac{1}{2}$ inches long, not attenuate at the base, spikelet less than $\frac{1}{8}$ inch. *Panicum bicknellii.* (13).

19. Spikelets roundish, not over $\frac{1}{16}$ inch long. 20.

19. Spikelets oblong-eliptic or eliptic, usually $\frac{1}{16}$ inch or more long. 21.

20. Nodes pubescent with appressed hairs, base of the leaves ciliate, panicle nearly as wide as long. *Panicum sphaerocarpon.* (14.)

20. Nodes glabrous, base of the leaves not ciliate, panicle not more than $\frac{1}{2}$ wide as long. *Panicum polyanthes.* (15).

21. Stems pubescent. *Panicum tsugetorum.* (23).

21. Stems glabrous. *Panicum boreale.* (18).

22. Spikelets glabrous. 23.

22. Spikelets pubescent. 24.

23. Nodes densely bearded. *Panicum microcarpon.* (17).

23. Nodes not bearded. *Panicum dichotomum.* (16).

24. Ligule at the top of the leaf sheath minute or absent. 25.

24. Ligule present. 26.

25. Nodes of the main stem glabrous or with a few hairs. *Panicum boreale.* (18).

25. Nodes of the main stem crisp pubescent. *Panicum ashei.* (27).

26. Upper sheaths glabrous (ciliate on the margin). *Panicum lindheimeri.* (19).

26. All of the sheaths pubescent. 27.

27. Upper surface of the leaves glabrous, except for a few long hairs near the base. *Panicum tsugetorum.* (23).

27. Upper surface of the leaves pilose. 28.

28. Outer empty glume acute; spikelet $\frac{1}{16}$ inch long pubescence on the sheath more than $\frac{1}{16}$ inch long. *Panicum villosissimum.* (21).

28. Outer empty glume blunt; spikelet less than $\frac{1}{16}$ inch long; pubescence on the sheaths not so dense and less than $\frac{1}{16}$ inch long. 29.

29. Upper surface of the leaf-blade long-pilose; plants yellowish-green. *Panicum hauchucae.* (20).

29. Upper surface of the leaf-blade long-appressed pubescent. *Panicum implicatum.* (22).

30. Spikelet $\frac{1}{8}$ inch or more long. 32.
30. Spikelet less than $\frac{1}{8}$ inch long. 31.
31. Spikelet less than $\frac{1}{16}$ in long. *Panicum polyanthes.* (15.)
31. Spikelet more than $\frac{1}{16}$ inch long. *Panicum commutatum.* (28).
32. Leaf sheaths mostly pappilose-hispid; nodes glabrous or short pubescent. *Panicum clandestinum.* (31).
32. Leaf-sheaths glabrous or soft-pubescent. 33.
33. Nodes glabrous. *Panicum latifolium.* (29).
33. At least the lower nodes pubescent or bearded. 34.
34. Lower surface of the leaf blade velvety-pubescent; leaf-sheaths hairy. *Panicum boscii molle.* (30a).
34. Lower surface of the leaf blade not velvety-pubescent. 35.
35. Panicle narrow, its branches appressed, rarely a little spreading; upper nodes at least, not bearded. *Panicum xanthophysum.* (26).
35. Panicle open, its branches spreading; the nodes appressed-pubescent. *Panicum boscii.* (30).

SPECIES DESCRIPTIONS.

1. **Panicum agrostoides** Spreng. Agrostis-like Panic-grass. An erect, rather stout, glabrous, perennial, $1\frac{1}{4}$-$3\frac{1}{2}$ feet high; sheathes loose; blades flat, $\frac{3}{4}$-$1\frac{1}{4}$ inches long, $\frac{1}{4}$-$\frac{1}{2}$ inch wide; inflorescence a panicle, purplish, oblong-ovate, 6-12 inches long, stiffly ascending, parts of the panicle densely flowered; spikelets crowded, a few hairs on the short pedicel; second empty glume and lemma of the staminate flower sub-equal. Along shores. Erie county.

2. **Panicum stipitatum** Nash. Long Panic-grass. A branched perennial 3-5 feet high; leaf-blade 1 foot long, often purplish, acuminate, and scabrous; inflorescence a pyramidal, purplish panicle, 4-12 inches long, more open than in the proceeding species; spikelets secund, acuminate, crowded, second empty glume and lemma of the staminate flower equal; the outer empty glume about $\frac{1}{3}$ as long as the second; no hairs at the base of the spikelet. North-eastern Ohio to Lorain, Fairfield and Columbiana.

3. **Panicum virgatum** L. Tall Smooth Panic-grass. A tall tufted perennial from a creeping rootstock; 1-$2\frac{1}{2}$ feet tall, glabrous. Leaves long-acuminate, flat, 1 foot long, $\frac{1}{4}$-$\frac{1}{2}$ inches wide, narrowed toward the base, rough on the margin; panicle erect or spreading, 6-20 inches high and about as wide; spikelets ovate, acuminate; outer empty glume acuminate, half as long as the spikelet, 3-5 nerved; second empty glume longer than the other glumes, 5-7 nerved, and exceeding the fruit. Low ground, salt marshes or prairies. Variable. General.

4. **Panicum dichotomiflorum** Mx. Spreading Panic-grass. A glabrous, branching annual, becoming decumbent and geniculate. Sheathes loose, glabrous and somewhat flattened; leaves 6-20 inches long, $\frac{1}{4}$-$\frac{3}{4}$ inch wide, scabrous above or on the margin; panicle diffuse 4-16 inches long, spikelet crowded 1-8 inch long; lanceolate, acute, glabrous, sometimes purplish; outer empty glume $\frac{1}{4}$ as long as the spikelet. General.

5. **Panicum miliaceum** L. Millet Panic-grass. An erect or decumbent annual 8-20 inches high, hispid or sometimes glabrous. Sheathes papillose-hirsute; leaves 5-10 inches long, $\frac{3}{8}$-1 inch wide, generally pubescent; panicle dense, erect or spreading and drooping at maturity; spikelets ovoid-acuminate; outer empty glume $\frac{2}{3}$ as long as the spikelet, 5-7 nerved; second empty glume 13 nerved, slightly longer than the other glumes. In waste places. Lawrence, Erie, Richland introduced.

6. **Panicum capillare** L. Tumble Panic-grass. A stout sparingly branched, erect or decumbent annual, very sparingly branched; sheaths papillose-hirsute; leaves pubescent, 6-12 inches long; $\frac{3}{16}$ to $\frac{5}{8}$ inches wide; panicle very large and diffuse, included until maturity; spikelets about $\frac{1}{16}$ inch long; outer empty glume $\frac{1}{4}$–$\frac{1}{2}$ as long as the spikelet; second empty glume exceeding the fruit. In dry soil as a bad weed. General and abundant.

7. **Panicum gattingeri** Nash. Gattinger's Panic-grass. Similar to P. capillare but branching from all the nodes. Panicles more numerous but not so spreading or diffuse, leaves less hirsute. Moist open ground. Rather general.

8. **Panicum flexible** (Gatt.) Scrib. Wiry Panic grass. A slender erect annual $\frac{1}{2}$ to 2 feet high with a few erect branches. Bearded at the nodes; sheaths papillose-hirsute; leaves 4-10 inches long; $\frac{1}{16}$ to $\frac{3}{16}$ inches wide or wider; more or less pubescent; panicle narrow, 4-9 inches long, about half the entire length of the plant; spikelets less than $\frac{1}{8}$ inch long, solitary at the ends of the branchlets; outer empty glume $\frac{1}{4}$ as long as the spikelet; second empty glume long acuminate. Adams, Champaign, Madison, Franklin, Erie, Cuyahoga.

9. **Panicum philadelphicum** Bernh. Philadelphia Panic-grass. A slender erect, freely-branching annual, decumbent at the base, 6-16 inches high. Leaves less than 4 inches long, $\frac{1}{16}$ to $\frac{3}{16}$ inch wide; panicle $\frac{1}{3}$ the entire length of the plant, few flowered, spikelet $\frac{1}{16}$ inch long, solitary or in 2's at the end of the divergent branchlets, eliptic, acute, smooth; outer empty glume $\frac{1}{3}$ the length of the spikelet; inner empty glume and lemma of the sterile flower equal and barely longer than the fruit. In dry woods or sandy shores. Ottawa county.

10. **Panicum depauperatum** Muhl. Starved Panic-grass. An erect or ascending dichotomous perennial, 8-16 inches high. Nodes ascending pubescent; upper sheaths shorter than the internodes, glabrous or pilose; leaves erect, elongated, $\frac{1}{16}$ to $\frac{1}{8}$ inch wide; primary panicle much exserted, lower panicle often hidden in the leaves; spikelets $\frac{1}{8}$ inch long, glabrous, acute; the second empty glume extending beyond the fruit. In dry soil. Cuyahoga county.

11. **Panicum linearifolium** Scrib. Linear-leaf Panic-grass. A densely tufted perennial, 8-22 inches high; culms glabrous, erect,

very slender, spreading or drooping; sheaths as long or longer than the internodes; leaves glabrous or pilose, especially on the lower surface; 4-10 inches long, $\frac{1}{16}$ to $\frac{1}{8}$ inch wide; primary panicle loose and open; spikelets obtuse or acutish, pubescent with spreading hairs; outer empty glume $\frac{1}{4}$ to $\frac{1}{3}$ as long as the spikelet. In woods. Rather general.

12. **Panicum werneri** Scrib. Werner's Panic-grass. A smooth, light colored, tufted, sparingly branched or simple perennial 6-18 inches tall. Leaves erect, linear, acuminate 2-4 inches long, $\frac{1}{8}$ to $\frac{3}{16}$ inch wide; panicle loose and open and usually included within the leaves; spikelets $\frac{1}{16}$ inch long, somewhat pubescent; outer empty glume $\frac{1}{4}$ as long as the spikelet, 1 nerved; the second empty glume 7 nerved. In the dryer parts of swamps. Lake, Cuyahoga, Franklin, Athens.

13. **Panicum bicknellii** Nash. Bricknell's Panic-grass. A slender, erect or decumbent perennial 8-16 inches tall. Lower internodes puberulent; sheaths ciliate on the margins, the lower ones pubescent; leaves ciliate and narrow at the base, erect, linear-lanceolate, primary leaves 3-7 inches long, $\frac{1}{8}$ to $\frac{5}{16}$ inch wide; panicle 3-4 inches or less long, the primary ones longer than the secondary ones; spikelet oval, or ovate, pubescent, hairs ascending; outer empty glume 1-nerved; the second empty glume 9-nerved. Dry woods. Gallia county.

14. **Panicum sphaerocarpon** Ell. Round-fruited Panic-grass. An almost simple, usually erect perennial with somewhat pubescent nodes. Sheaths shorter than the internodes, ciliate on the margin, glabrous; leaves 1-4 inches long, $\frac{1}{8}$ to $\frac{1}{2}$ inch wide, acuminate, ciliate toward the base; panicle ovoid, long-exserted, 1-3½ inches long, loosely flowered; spikelets greenish to purplish, $\frac{1}{16}$ inch or less long. Dry or sandy soil. Cuyahoga, Summit, Trumbull, Hocking, Sciotc.

15. **Panicum polyanthes** Schultes. Many-flowered Panic-grass. An erect, smooth, light-green perennial 1 to 3 feet tall. Sheaths usually longer than the internodes; leaves ciliate toward the base, long-acuminate, all of about the same size, 5 to 8 inches long; ½ to 1 inch wide; panicle 3 to 9 inches, longer than wide, branches slender; spikelets $\frac{1}{16}$ inch long, numerous, ovoid to spherical; outer empty glume minute; second empty glume 7 nerved. Woods. Fairfield, Hocking, Jackson.

16. **Panicum dichotomum** L. Forked Panic-grass. A smooth perennial or having the lower nodes barked, erect, purplish from a rootstock. Sheaths about ½ the length of the internodes; leaves light green to purplish, spreading, 2 to 4 inches long, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide; panicle 1½ to 3½ inches long, primary panicle much exserted, secondary panicle included; few spikelets borne at the ends of the long, flexuous branches of the panicle; spikelets $\frac{1}{16}$ inch long, glabrous, or rarely pubescent; outer empty glume

minute, second empty glume shorter than the fruit, faintly nerved. Woods. Rather general. No specimens from the northwestern counties.

17. **Panicum microcarpon** Muhl. Small fruited. Panic-grass. A perennial, simple at first, later densely branched, prostrate or leaning, reflexed barbs at the nodes. The primary leaves 3 to 4½ inches long, ½ inch wide, secondary leaves 1 to 2 inches long, $\frac{1}{16}$ to $\frac{1}{8}$ inch wide, smooth; primary panicle long exserted, rigid, 3 to 4½ inches long; secondary panicle smaller, lax and included; spikelets about $\frac{1}{16}$ inch long, purplish, glabrous; outer empty glume $\frac{1}{3}$ as long as the spikelet; second empty glume slightly longer than the spikelet. Moist soil. Cuyahoga, Lorain, Erie, Fairfield, Hocking, Jackson, Adams.

18. **Panicum boreale** Nash. Northern Panic-grass. An erect, simple, perennial 1-2 feet tall, later becoming somewhat branched and decumbent. Leaves erect, glabrous or rarely puberulent beneath, sparingly ciliate toward the base; Panicle 2 to 4 inches long; narrow, ascending and spreading loosely flowered; spikelets $\frac{1}{16}$ inch or slightly longer, outer empty glume $\frac{1}{3}$ as long as the second empty glume; second empty glume as long as the fruit. Moist open ground or woods. Fulton county.

19. **Panicum lindheimeri** Nash. Lindheimer's Panic-grass. An erect or spreading dichotomous perennial, glabrous, or pubescent below. Nodes swollen, internodes longer than the sheaths ligule of hairs at the top of leaf sheath $\frac{1}{16}$ to $^3/_{32}$ inches long; leaves 2 to 3¼ inches long, ¼ to $\frac{5}{16}$ inches wide; ascending when young with a few hairs on the margin of the base, glabrous above and glabrous or puberulent below; primary panicle long-exserted 1 to 2½ inches long, about as broad as long, loosely flowered, ascending or spreading; spikelet somewhat pubescent, purplish, less than $\frac{1}{16}$ inch long; outer empty glume minute; second empty glume shorter than the fruit. Sandy woods and open grounds. Ashtabula, Hocking.

20. **Panicum hauchucae** Ashe. Hairy Panic-grass. A perennial, erect and simple at first, later profusely branched and somewhat decumbent. Nodes barbed; sheaths papillose-hirsute; ligule of hairs $\frac{1}{16}$ inch or less long; leaves erect or spreading, thin lax or firm, upper surface pilose, lower surface appressed-pubescent with a luster; panicle 2 to 4 inches long, secondary shorter than the primary, branches ascending or spreading; spikelets pubescent, 1-16 inch or less long; outer empty glume minute; second empty glume papillose-pilose, slightly shorter than the fruit. Prairies or open ground. General.

21. **Panicum villosissimum** Nash. Villous Panic-grass. A villous, olive green, erect or ascending slender perennial. Sheaths villous with spreading hairs, ligule at the top of leaf sheath $\frac{1}{8}$ to $\frac{3}{16}$ inch long; leaves firm, ascending, 2¼ to 4 inches long, $\frac{1}{4}$

to $\frac{3}{8}$ inch wide, slightly involute toward the end, pilose on both surfaces, hairs appressed on the upper surface; primary panicle long-exserted or equaled by the uppermost leaf, loosely flowered; spikelets a little more than $\frac{1}{16}$ inch long, obovate to eliptic, densely pubescent with short spreading hairs; outer empty glume a little less than $\frac{1}{2}$ as long as the second empty glume; second empty glume a little shorter than the fruit. Sandy or dry soil. Cuyahoga, Erie, Licking.

22. **Panicum implicatum** Scrib. Slender stemmed Panic-grass. A slender, more or less pubescent tufted and erect perennial. Sheaths shorter than the internodes, papillose-pilose; ligule at the top of the leaf sheath $\frac{3}{16}$ inch or less; leaves 1 to 3 inches long, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide, erect, lanceolate, firm, upper surface pilose, hairs erect, hairs on the lower surface appressed; panicle open, wide-spreading, flexuous, $1\frac{1}{4}$ to 2 inches long, branches sometimes tangled; spikelets about $\frac{1}{16}$ inch long, obovoid, obtuse, papillose-pilose; outer empty glume almost $\frac{1}{2}$ as long as the spikelet, pubescent; second empty glume equaling the fruit. Wet soil. Gallia county.

23. **Panicum tsugetorum** Nash. Hemlock Panic-grass. A bluish-green or purplish, slender perennial, 10 to 20 inches ascending or spreading, often geniculate below. Sheaths appressed pubescent, shorter than the internodes; leaves 2 to $2\frac{1}{2}$ inches long, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide, minutely appressed-pubescent beneath, glabrous above or with a few hairs near the base or margin; panicle loosely flowered, branches ascending or spreading; spikelets about $\frac{1}{16}$ inch long, broadly ovate, pubescent; outer empty glume $\frac{1}{3}$ as long as the spikelet; second empty glume equalling the fruit. Sandy woods. Defiance, Summit.

24. **Panicum leibergii** (Vasey) Scrib. Leiberg's Panic-grass. A perennial 1 to $2\frac{1}{2}$ feet tall, scabrous at least below the nodes. Sheaths sometimes longer than the internodes, papillose-hispid, hairs spreading; ligule minute; leaves ascending, lanceolate, ciliate near the base, papilose-hispid on both sides or almost glabrous above, 3 to 6 inches long; panicle 3 to 6 inches long, less than $\frac{1}{2}$ as wide, branches ascending; spikelets $\frac{1}{8}$ inch long, papillose-hirsute with spreading hairs; outer empty glume $\frac{1}{2}$ as long as the spikelet, 1 to 3 nerved; second empty glume oval, 7 to 9 nerved. Dry soil. No specimens.

25. **Panicum scribnerianum** Nash. Scribner's Panic-grass. An erect perennial 6 to 14 inches high, in clumps. Sheaths papillose-hispid or nearly glabrous; ligule $\frac{1}{32}$ inch long; leaves 2 to 4 inches long, $\frac{1}{8}$ to $\frac{7}{16}$ inch wide, sometimes ciliate toward the base; panicle short-exserted, $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long; spikelets $\frac{1}{8}$ inch long, turgid, obtuse, slightly pubescent, outer empty glume minute, second empty glume shorter than the fruit. Sandy or dry soil. Cuyahoga, Erie, Wood, Franklin.

26. **Panicum xanthophysum** Gr. Slender Panic-grass. A tufted, yellowish-green ascending perennial 1 to 2 feet tall, simple. Sheaths loose, sparingly papillose-pubescent; ligule minute; leaves 3 to 6 inches long, $\frac{1}{4}$ to $\frac{3}{4}$ inch wide, often widest at the middle, strongly nerved, glabrous except near the ciliate base; panicle short to long exserted, few flowered, branches erect; spikelets $\frac{1}{8}$ inch long, or slightly more, obovate, turgid, pubescent, or rarely glabrous; outer empty glume about $\frac{1}{2}$ as long as the spikelet, second empty glume and lemma of the sterile flower equal. Dry soil. Rare. Lake county.

27. **Panicum ashei** Pear. Ashe's Panic-grass. An erect, stiff, usually sparingly branched, purplish perennial, in loose clumps 10 to 20 inches high. Sheaths short-ciliate on the margin, pubescent, shorter than the internodes; leaves 2 to $3\frac{1}{4}$ inches long, $\frac{3}{16}$ to $\frac{1}{2}$ inch wide, rigid, spreading or ascending, glabrous, ciliate near the base; panicle 2 to 4 inches long, branches ascending; spikelets purplish, a little more than $\frac{1}{8}$ inch long, obtuse; outer empty glume minute. Dry woods. Cuyahoga, Lake, Trumbull, Fairfield.

28. **Panicum commutatum** Schultes. Variable Panic-grass. A stout, erect, perennial, glabrous, except for the puberulent nodes, 8 to 30 inches high, dichotomously branched above. Sheaths glabrous or puberulent toward the summit, ciliate on the margin, sheaths generally shorter than the internodes; leaves firm, cordate clasping, glabrous or puberulent 2 to $4\frac{1}{2}$ inches long, $\frac{3}{8}$ to $\frac{3}{4}$ inches wide; panicle 2 to 5 inches long, spreading; spikelets less than $\frac{1}{8}$ inch long, eliptic, obtuse; outer empty glume minute; second empty glume as long as the fruit, 7 nerved, pubescent. Dry woods. Lawrence, Gallia, Fairfield, Wayne.

29. **Panicum latifolium** L. Broad-leaf Panic-grass. An erect smooth, perennial, simple or branched above, 1 to 3 feet high. Sheaths smooth and glabrous, ciliate; leaf-blades 2 to 7 inches long, $\frac{3}{4}$ to $1\frac{1}{2}$ inch wide, cordate, clasping at the base, acuminate, glabrous or nearly so, ciliate, panicle $2\frac{1}{2}$ to 6 inches long, short or long exserted, rarely included, ascending, rather few flowered; outer empty glume almost $\frac{1}{2}$ as long as the spikelet, acuminate; second empty glume oval, obtuse 9 nerved, pubescent. In woods. General.

30. **Panicum boscii** Poir. Bosc's Panic-grass. A glabrous or minutely pubescent perennial 1 to $2\frac{1}{2}$ feet, bearded with reflexed hairs at least at the lower nodes. The sheaths usually glabrous or pubescent on the margin and at the summit, leaves ovate to broadly lanceolate, 2 to 5 inches long, $\frac{1}{2}$ to $1\frac{1}{4}$ inches wide, pubescent below, slightly pubescent or glabrous above; panicle $2\frac{1}{2}$ to 4 inches long, usually nearly as wide; spikelets $\frac{1}{8}$ to 3-16 inch long, ovate; outer empty glume $\frac{1}{3}$ to $\frac{1}{2}$ as long as the spikelet. Warren, Adams, Jackson and Belmont.

30 a. **Panicum boscii molle** (Vasey) Hitchc. and Chase. Much like P. boscii except not quite so tall and downy pubescent thruout. Hamilton, Lawrence, Cuyahoga.

31. **Panicum chandestinum** L. Hispid Panic-grass. An erect or ascending rather stout perennial, simple at first but much branched later in the season. Sheaths longer than the internodes, papillose-hispid, especially the upper ones; leaf-blades 2 to 8 inches long, ½ to 1¼ inches wide, cordate, clasping, glabrous, ciliate at the base; primary panicle 3 to 5 inches long, branches ascending, often long-exserted, secondary panicles often inclined; spikelets $\frac{1}{8}$ inch long, pubescent, eliptic; outer empty glume $\frac{1}{3}$ as long as the spikelet; the second empty glume 9 nerved. In moist thickets. General.

MEETINGS OF THE BIOLOGICAL CLUB.

Orton Hall, February 2, 1914.

The meeting was called to order at 7:30 by the President, Mr. Kostir. The minutes were read and approved. The following were elected to membership: Eric S. Cogan, Fred Perry, Gertrude Bartlett, Malon Yoder, Rudolf Pintner and Newton T. Miller.

The first paper of the evening was a review of the thesis on the study of "Capillary Movement of Soil Moisture," by Malcolm Sewell. There are three reasons why a plant may not get sufficient water. First the soil water may be gone, second the transpiration may be greater than the absorption and thirdly the transpiration may be greater than the capillary action of the roots. A plant may draw water from a much larger area than that in which the roots are, due to capillary action. Mr. Sewell then showed a dozen or more slides showing pictures of his tanks in which he grew the corn on which he based his conclusions. One tank had no concrete bottom. The others had concrete bottoms in which he kept the water levels at three and five feet, respectively. He found that the best results were obtained in the tank without a concrete bottom.

Prof. Osborn next gave an illustrated talk on his trip to Maine. He said that there is little known about Maine and that much of the State is unexplored. Much of the timber is wasted by poor means of lumbering. The path that he took up Mt. Katahden was that of an old avalanche. The trip up was a hard one due to the rough out-crop of huge rocks. The purpose of his trip was to collect leafhoppers.

Mr. Reed gave a review of some papers read at the meeting of physiologists held in Philadelphia.

Blanche McAvoy, *Secretary.*

MEETING OF THE EXECUTIVE COMMITTEE OF THE OHIO ACADEMY OF SCIENCE.

On the call of President Mendenhall, a meeting of the Executive Committee of the Ohio Academy of Science was held on May 2, in the Biological Building of the Ohio State University. The invitation was extended to the officers of the Academy to meet with the Committee.

Professors Mendenhall, Hine, Walton and Rice, of the Committee, were present; also Professors Osborn, Lazenby, Mills, Schaffner and Cole.

It was unanimously voted that the invitation of the Ohio State University to hold the next Annual Meeting of the Academy in Columbus, be accepted with thanks. Voted that the Executive Committee recommend to the Annual Meeting of the Academy the holding of a field meeting during the month of May of 1915.

Voted that the President and Secretary be authorized to appoint a representative to consult with the Secretary of State of Ohio and to take such steps as may be necessary to secure the change of the corporate name of the Academy from "The Ohio *State* Academy of Science" to "The Ohio Academy of Science" in conformity with the revised constitution and the general usage of the Academy. Prof. Lazenby was appointed after the meeting.

Voted that the President be requested to communicate with Governor Cox with a view to securing closer mutual relations between the Ohio Academy of Science and the State Government.

A careful discussion of the relations of the Ohio Academy of Science and the Ohio Naturalist showed a general sentiment in favor of a broadening of both scope and title of the Naturalist to correspond with the broadening scope of the Academy, as shown especially in the recent organization of a Section for Physics. As the result of this discussion, it was voted that the recommendation be presented to the publishers of the Ohio Naturalist that the name of that journal be changed for the year 1914-1915 to "The Ohio Naturalist and Journal of Science," with a view to the further change in 1915-1916 to "The Ohio Journal of Science;" also voted that the Editor and Business Manager of the Naturalist be requested to report to the Annual Meeting concerning the advisability of the financial co-operation of the Academy in the publication of the Naturalist.

EDWARD L. RICE, *Secretary*.

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A CYTOLOGICAL STUDY OF THE STAMENS OF SMILAX HERBACEA*

LILLIAN E. HUMPHREY.

INTRODUCTION.

There seems to be a general agreement among the various investigators of the reduction division, that there is a pairing and conjugating, in the first reduction division, of the univalent chromosomes to form bivalents, but there is a considerable diversity of opinion as to the time of the pairing and fusion. Allen, Gregoire, Overton and many others hold the view that there is a side to side pairing of the chromatic elements occurring usually about the time of "synapsis." De Vries also claimed that there is a side to side pairing, but was not certain when it occurred, although it was some time before the separation of the halves of the bivalent chromosomes. As a proof of this theory it was held that, since a longitudinal split of the spirem is discernible in the early stages of the reduction division, the double spirem was the result of a conjugation of two simple spirems. But according to Schaffner, Farmer and Moore, Mottier and others the early split is a longitudinal division of the same nature as that which occurs at each vegetative karyokinesis. The pairing of the univalents according to this view must occur very early, before the formation of the spirem; and the protochromosomes, which in some species are rather definite masses and approximate the reduction number of chromosomes, probably represent the end of the stage when the pairing occurs.

* Contribution from the Botanical Laboratory of the Ohio State University, No. 85.

In my studies, therefore, careful observations of the spirem were made with the view of determining whether there is a continuous thread or whether there are a number of short individual threads interwoven but distinct as described by Lawson and others in a number of cytological studies of plants more or less closely related to S. herbacea.

The exact manner of chromosome formation was also studied to determine whether they were the result of a looping and a later longitudinal folding, or if there was simply a transverse constricting and breaking apart of the spirem to form the chromosomes as described by Miss Elkins in Smilax herbacea.

It was with these points in view that this study and review of the necessary literature was taken up under the guidance of Prof. John H. Schaffner, whose assistance and advice was found to be of inestimable help in all work undertaken with him.

GENERAL CONSIDERATION OF PAST LITERATURE ON THE SUBJECT.

Since in recent years all except the latest papers have been repeatedly reviewed, it is not considered necessary to refer to any except such as have a very direct bearing on the matter in hand. Those dealing with plants closely related to Smilax herbacea are however included so far as they are available for study.

Miss Elkins in her paper, "The Maturation Phases in Smilax herbacea," states that she did not find a distinct reticulum in the microsporocytes, and often the chromatin bodies were in pairs or fours scattered through the finely granular meshes. According to her account the multinucleolate condition is the rule rather than the exception and often the nucleoli have papillate projections which are present quite late. At "synapsis" or contraction there is never more than one nucleolus present which condition is brought about by the union of the nucleolar elements, but often there are dark staining bodies left in the nuclear cavity. She also found that the nucleolus disappears at the metaphase just as Gates found for Oenothera rubrinervis. In the presynaptic stages, the linin meshes are said to contract, drawing the chromatin material together, while the nucleolus is at one side projecting from a mass of threads. It is during this period that she found the chromatin becoming arranged into an interwoven beaded filament. The appearance of the nucleus after synizesis is stated to be quite different from its previous condition, the chromatin emerging as a homogeneous filament. It is also vaguely suggested that this may facilitate proper placing of the paired parental elements in the chromosomes in the spirem. She says that the chromosomes do not appear as definitely united until the segmentation of the spirem. After synizesis the spirem is a fairly thick thread, slightly beaded, but in a short time becomes homogeneous. She observed that the double character of the

spirem was discernible at this time and at intervals the spirem, which is made up of previously paired chromatin elements, was constricted in some places to a narrow thread and finally separated into irregularly shaped double segments. These pieces continue to thicken and shorten, forming X and V-shaped chromosomes. She says that the first division is merely a separation of the chromosomes, but the second is a true mitosis. At the telophase, she observed that the spirem was disposed about the periphery of the newly formed membrane. The nuclear membrane disappears and the spirem is spread out over the spindle and in a short time the spirem contracts into the equatorial plane, dividing into chromosomes which become attached to the spindle with the open ends outward. She could not determine the exact number of chromosomes, but decided that there were either twelve or thirteen.

Schaffner found in his study of Erythronium that the spirem was at first long, slender, with chromatin granules that are not prominent before the looping. The spirem undergoes a contraction and a preceptible thickening, and is thrown into twelve loops which are apparently broken apart by the twisting and contracting. The chromosomes are said to be of various sizes and seem to be double. They are attached to the spindle near the free ends and during metakinesis are uncoiled and pulled apart in the middle.

In Lilium tigrinum, (13), he found the chromatin network forming a thin spirem with a single row of spherical granules. There were no free ends so this would point to the fact that the spirem is continuous and is also free in the cavity. The spirem was then found to be in a condition of contraction and there was not any apparent change in the spirem after it had come out of this condition. After this the linin thread is said to elongate. The spirem also has a tendency to form into loops. Twelve loops are formed which break up into twelve chromosomes. These are attached to the spindle fibers near the free ends in the mother star and are separated by a transverse division. The split in the second division is a longitudinal one.

When working with Agave virginica (15), he found that there was a course chromatin net present and the cytoplasm was dense and spongy. The chromatin net stretched out and formed bivalent protochromosomes which in turn formed a delicate spirem with a single row of granules. Synizesis followed, and in a study of the living material no contraction of the chromatin material was noticeable. After synizesis a transverse division of the chromatin granules takes place with a shortening and thickening of the spirem which is thrown into loops of various sizes and pressed against the wall of the nuclear cavity. With the breaking of the spirem there results three ring chromosomes,

five smaller, and four large, long ones, which are rather well individualized. The chromosomes are attached to a bipolar spindle and are said to undergo a transverse splitting or breaking at the loop end in the first division and a longitudinal separation occurs in the second.

Lawson made a study of the microspores of several plants and arrived at a number of new conclusions in regard to the relation of "Osmosis as a Factor in Mitosis," (5). He said that the nuclear membrane did not break down or disappear during the development of the spindle, but acted as any permeable membrane would under varying osmotic conditions. He gave drawings showing that when the amount of nuclear sap became very much reduced, the membrane drew close to each chromosome and finally there were as many osmotic systems as there were chromosomes and each chromosome has its own sphere of "kinoplasm." He holds that the achromatic spindle is simply an expression of the tension of the cytoplasm and is not an active factor in mitosis.

In his paper, "The Phase of the Nucleus known as Synapsis," (4), he states that the condition described is not a contraction at all and has nothing to do with the fusion of maternal and paternal chromatin, so was not a critical stage in reduction. In his study of Smilacina he did not find protochromosomes, but the reticulum was found to be made up of a number of linin threads which approximate the diploid number of chromosomes. Since he found no vacuoles in the cytoplasm he concluded that the nuclear cavity itself was acting as a vacuole, since the sporocytes were still enlarging and also on account of the turgid appearance of the nucleus. By the stretching of the nuclear membrane, the space within was increased causing a great osmotic pressure, which he concluded facilitated growth. This condition is probably synonymous with that described by many authors as "synaptic contraction." By actual measurements he stated that he was able to determine that there was no contraction whatever. Thus the conclusion reached in the paper was, that "synapsis" is simply a period of growth during which the great amount of nuclear sap causes the nuclear membrane to distend and withdraw from the chromatin material. This was all explained as occurring before reduction division, because all the sporocytes had merismatic activity which manifests itself in the two divisions immediately following.

Schaffner in his paper, "Synapsis and Synizesis" (14), defines synapsis as the formation of bivalent chromosomes from univalent ones by an end to end fusion and a subsequent folding. McClung's term Synizesis was accepted as appropriate for the contractions usually observed in prepared sections showing early stages in reduction. Synizesis was explained as an artifact probably due to plasmolysis.

Sauer, when investigating Convallaria majalis (10), found that there was a resting period after the last archesporial division, but that in a short time a chromatin network was formed. The nucleous described as being visible from the beginning, fragments in the later stages forming several micronucleoli. He says that there is a clear area in the nucleus and that the continuity of the spirem is very evident. After synizesis a loosening and unwinding of the thread begins. The linin thread becomes thicker and the chromatin granules elongate. Altho the spirem is shorter it occupies the whole cavity and the division of the granules is apparent. After this stage the doubleness of the spirem is no longer visible. The spirem is next thrown into sixteen loops which later divide into sixteen chromosomes. The first division of the chromosomes in the microsporocytes is transverse and therefore qualitative.

Miss Hyde found in Hyacinthus orientalis (3), a definite network in the microsporocyte, but fails to discover any accumulation of chromatin material that might be interpreted as protochromosomes. She determined, however, that the complicated spirem was continuous, undergoing synizesis, looping, and finally breaking into eight well individualized chromosomes.

Miss McAvoy, in her observations of the reduction division in Fuchsia (7), found protochromosomes which seemed to stretch out and form a continuous spirem with chromatin granules. The spirem undergoes synizesis after which the delicate thread soon begins to thicken and in a short time shows loops which lie along the periphery of the nucleus. These loops, fourteen in number, break apart to form fourteen chromosomes.

The study that she made of Oenothera biennis (8), served to confirm the results stated in her previous paper in as much as she found a reticulum and protochromosomes which in turn formed a continuous spirem that could be traced its entire length. The synizetic knot is not so tight as in some plants and even in this stage she was able to trace out much of the spirem. Loops were formed which break apart forming seven chromosomes.

MATERIALS AND METHODS.

The primary purpose of this study was to observe the reduction division in the microsporocytes of Smilax herbacea and also to incidentally consider any peculiarities in relation to the degeneration of normal stamens to vestigal structures or to their complete disappearance. It was found, however, that the material available did not give the more critical stages bearing upon the second part of the problem.

The material used in the investigation was collected from the first week in May, 1913, at Columbus, Ohio, to the middle of June, 1913, near the Lake Laboratory at Cedar Point. The

buds were killed in Schaffner's weaker chrom-acetic acid with a trace of osmic acid added, being left in this for twenty-four hours. After being thoroughly washed in water, the material was dehydrated by passing it through the various grades of alcohol to 70%, where it was left until September, when it was passed through the higher grades into chloroform, from which it was gradually passed into pure parafine and imbedded. Sections 10μ to 13μ thick were cut.

Several methods of staining were used. The first tried was analin safranin, which was a fairly good stain, but it did not make enough differention between the chromatin material and the cytoplasm to be easily studied. Next Heidenhain's iron-alum haemotoxylin was used and found to be very good, staining the chromatin material black and the surrounding tissues brownish. In using this stain, the slides were passed through turpentine, xylol, the different grades of alcohol to water, then passed into iron-alum, where they were left for two hours; after being well washed in water they were left four hours or longer in Heidenhain's haemotoxylin after which they were washed and placed in iron-alum to clear, and after dehydrated they were mounted in Canada balsam. The most satisfactory stain was Delafield's Haemotoxylin. The slides were passed through the alcohols to 25%, then into Delafield's Haemotoxylin where they were left for two hours, after which they were washed in water and passed up through the alcohols and mounted.

INVESTIGATION.

The earliest preparations show the resting cells after the last archesporial division, but before the tapetum has become differentiated. In the youngest sporocytes the nuclei are small, measuring 9μ or 10μ, and the cells fit closely together forming a compact mass. In many nuclei there are several nucleoli present which do not appear spherical, but have one or more finger-like projections. In the youngest sporocytes the chromatin material seems to be arranged in a loose reticulum (Fig. 1), which is not uniformly spaced throughout the nuclear cavity, and is easily distinguished in it. Following this reticular stage the chromatin material has a tendency to draw together in masses which are rather definite in shape, spongy and flaky in appearance, and have fine threads radiating in all directions from the central lumps. (Fig. 2).

There is a tendency for these spongy masses to become more compact and definite in shape, approximating the reduced number of chromosomes, (Fig. 3), and without doubt these are the protochromosomes described by various authors, and designated as "prochromosomes" by Overton and Strasburger. It is probably at this stage that the univalent chromosomes are paired in

order that they may have a definite position in the spirem during the synaptic stages when the bivalent chromosomes are formed by an end to end pairing and later longitudinal folding of the chromatic elements. By many investigators "synapsis" is used to designate the period of contraction which very generally appears in the earlier stages of reduction. But it is much better to use the term synizesis as was suggested by McClung and adopted by Schaffner in the more recent of his cytological papers. By eliminating this confusion of terms such expressions as "synaptic mates," etc. in relation to the chromosomes, become intelligible without further explanations.

The protochromosomes do not retain a definite shape, but in a short time there is an apparent elongation of each mass and a tendency for the delicate connecting linin threads to become thicker as the elongation continues. (Figs. 4, 5, 6). Soon no traces of the flaky masses are left, but instead there is a very delicate continuous spirem which can be traced for long distances in many of the sporocytes without finding any free ends. The free ends in most cases can all be accounted for by their having been cut in sectioning. (Fig. 7).

There is now a perceptible enlargement of the nucleus, which appears very turgid; as a result of this enlargement the very delicate spirem becomes loosened from the nuclear membrane and does not appear to be so uniformly arranged about the periphery as before, but has the appearance as if it had been treated with some plasmolizing reagent. (Fig. 8).

By this time there is usually one large nucleolus present, which very seldom appears in a central position and sometimes there are also dark staining granules in the nuclear cavity which in all probability are minute nucleoli. Miss Elkins noted this same fact in her study of Smilax herbacea.

The spirem and granules in the earlier division stages show no evidence of a double character. Soon after the spirem has become loosened from the nuclear wall, there is an irregular massing of the thread, which either may or may not enclose the nucleolus. (Figs. 9, 10, 11). The types of contraction are not always the same and there was no evidence that synizesis is an actual stage in the reduction division. As previously mentioned Lawson considered this condition to be due to a period of growth in the nucleus, there would be thus no actual shrinking of the chromatin, but there can be no question that in the preparations studied there was a considerable actual contraction. Schaffner (15) regarded this condition as an artifact on account of experiments tried with living material of Agave virginica and the reactions also obtained by the treatment with different reagents which caused plasmolysis to take place in the vegetative cells, giving the spirem much the same appearance that was found in

many reduction preparations of apparently the same age. Miss Elkins regards this "synapsis" as a natural stage in the reduction division and not as an artifact as the many types of synizetic masses lead the writer to believe. The synizetic knot is not necessarily found to one side of the nuclear cavity, but is often in the center in which case the nucleolus is usually found to be lateral in position. Often threads with numerous granules are seen projecting from the greater mass of chromatin material toward the periphery of the nucleus. Before the contraction of the spirem, there were no double granules observed and the spirem was single, but following synizesis a heavy spirem extends throughout the nuclear cavity touching the periphery at various points. (Figs 12, 13, 14). No evidence whatever in favor of the theory that the double spirem is the result of the conjugation of two simple spirems was found. The evidence rather points to a longitudinal splitting instead of a conjugation. (Fig. 14).

The heavy spirem which often showed very plainly its double character is thrown into loops around the periphery of the nuclear cavity and in an older sporocyte each incipient loop appeared to have twisted more tightly together, showing as definite bodies still connected together so that almost the entire length of the spirem may be traced by following the twists of the loops. Miss Elkins described the chromosomes as being formed by the halves of the double spirems constricting at intervals until only a very slender thread united the segments, but the writer found a number of preparations which showed well defined loops in which the twisted condition appeared plainly just at the time when they were pulling apart, as seen in Figure 17. Often large granules are seen upon the linin thread even after well twisted loops are formed and the double character of the thread is seen even in the fully formed chromosome, if one focuses carefully.

By the transverse pulling apart of the heavy looped spirem, there results rather indefinitely shaped chromosomes which are joined together for some time by very delicate threads. (Figs. 18, 19, 20, 24). The irregular masses tend to shorten and thicken forming twelve rather well individualized chromosomes. (Figs. 21, 22, 23). In many of the preparations of this stage it is impossible to count the chromosomes because of their proximity and the irregularity of shape.

After the chromosomes have acquired their individual shape they are still connected by fine threads (Fig. 24) and the nuclear membrane becomes indistinct while the incipient spindle appears about it. (Figs. 24, 25). The membrane disappears and a definite bipolar spindle is apparent from the beginning with the chromosomes and their connecting threads arranged over it. The chromosomes appear to be gradually pulled into an equatorial position by a shortening of the connecting threads. During this

change the nucleous disappears. It is not possible to discover whether it was dissolved or disintegrated into smaller bodies and ejected into the cytoplasm. The cytoplasm at this stage has a very spongy appearance, but no micronucleoli were seen in it.

In the mother star of the first division the chromosomes are attached to the spindle fibers near their free ends with the head of the loop extending outward as found by Schaffner in Lilium philadelphicum (11) and by Miss Hyde in Hyacinthus (3). There is a gradual shortening of the spindle fibers and at the same time the chromosomes uncoil and pull apart at the outer head of the loop or at the point where fusion took place during synapsis. From drawings of metakinesis it will be seen that the transverse splitting of the chromosomes of Smilax herbacea is not simultaneous as is found in many plants. (Fig. 27). After metakinesis the chromosomes are arranged around the poles forming the daughter stars of the first division. (Fig. 28). There is also a perceptible increase in the density of the cytoplasm in the equatorial region where in a short time a distinct cell plate is seen. By the time of the complete formation of the cell plate, the spindle is no longer visible and a new nuclear membrane is laid down around the daughter masses of chromatin material thus forming two new cells very similar to the parent cell, but much smaller. With the formation of the new nuclear membrane, it is also found that the nucleoli of the daughter cells are beginning to appear. The chromatin material in these daughter cells does not undergo such changes as were evident in the nuclei of the sporocyte, but the newly formed chromosomes are massed together not to form a continuous spirem, but an irregularly shaped mass in which the individual chromosomes may be distinguished. (Fig. 29).

The daughter cells do not immediately separate, but may be seen still clinging together after the second division is well advanced. In the second division the chromosomes are attached to the spindle fibers in the equatorial plane by the head of the chromosome, having the free ends extending outward. (Fig. 30). The separation of the chromosomes at this division is along the longitudinal split. After the second metakinesis we find the two daughter stars with the distinct chromosomes (Fig. 31) which were readily counted in several preparations from the polar views. The number was found to be twelve. (Fig. 32).

The cell plates of this division soon appear and a new nuclear membrane is evident in each daughter cell around the rather small chromosomes which become more or less crowded together and connected by fine connecting strands. All the tetrads appeared to be normal, there being no such irregularities found as shown by Fullmer in Hemerocallis and by Miss McAvoy in Fuchia.

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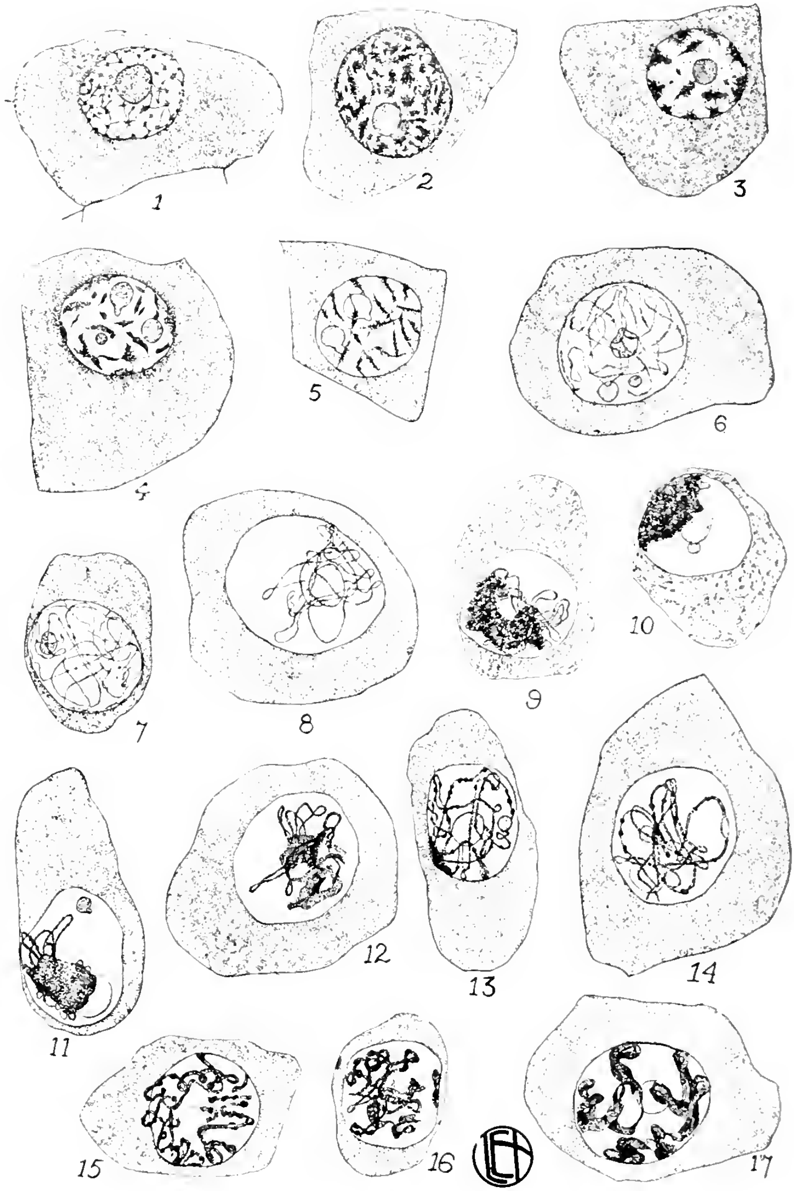
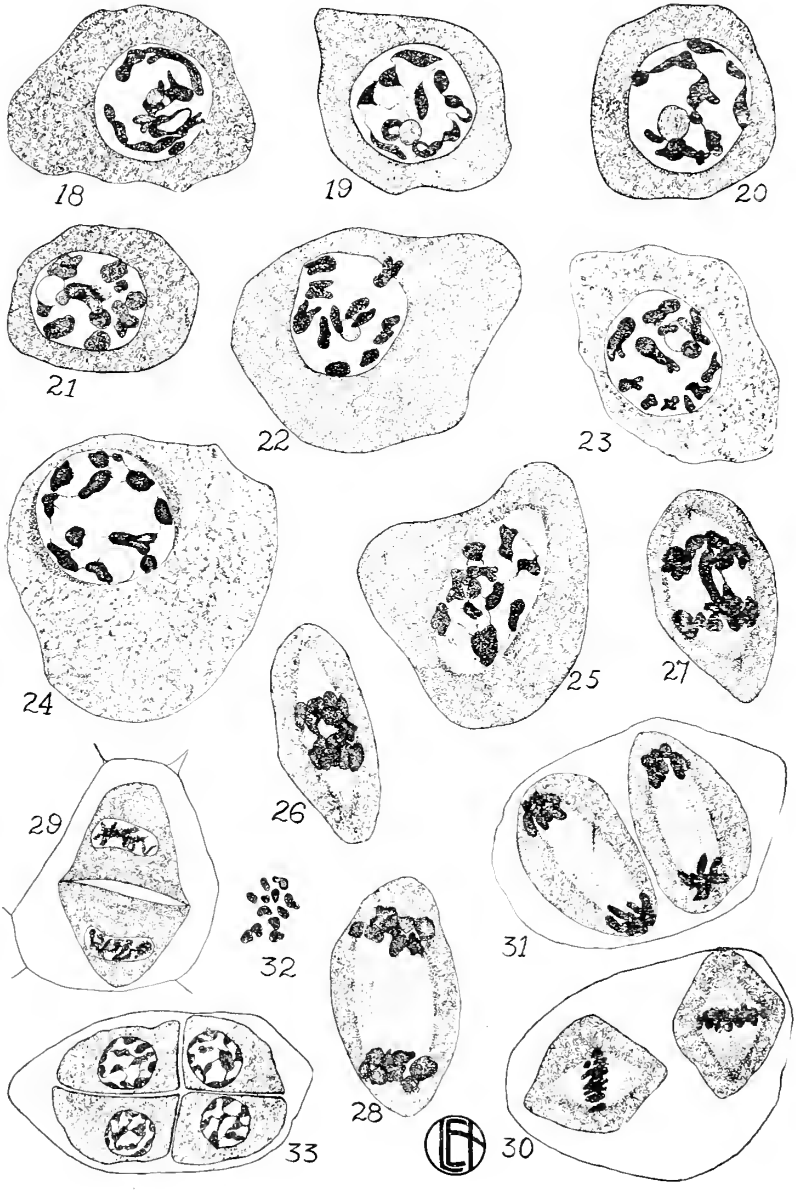
Explanation of Plates XVI and XVII.

The plates were reduced $\frac{5}{8}$ in reproduction. All the drawings were made with a compensating ocular 12 and a 1-16 oil immersion lens. An Abbe camera lucida was used.

Fig. 1. Microsporocyte before the beginning of the division of the chromatin network.
Fig. 2. Microsporocyte showing the flaky and spongy appearance of the chromatin material.
Fig. 3. Masses of chromatin material which are the protochromosomes.
Figs 4, 5. Later stages showing the elongation of the protochromosomes in their tendency to form a spirem by stretching out along the linin thread.
Fig. 6. Early spirem with irregular flakes along its sides.
Fig. 7. Early spirem with small granules.
Fig. 8. Microsporocytes showing the spirem free from the nuclear membrane and collapsing.
Figs. 9, 10. Sporocytes showing different types of synizesis.
Fig. 11. Sporocyte in synizesis with the projecting strands showing granules.
Fig. 12. A synizetic knot with rather heavy projecting loops.
Fig. 13. Heavy spirem showing granules and beginning of looping.
Fig. 14. Sporocyte showing the double nature of the spirem and granules.
Fig. 15. Sporocyte showing the early looping stage and double spirem.
Fig. 16. Sporocyte showing well formed loops.
Fig. 17. Chromatin loops completely formed and just breaking apart.
Figs. 18, 19, 20. Sporocytes showing the prominent chromosomes that have not completely separated, but still show some connecting threads.
Figs. 21, 22, 23. Sporocytes showing the twelve mature chromosomes; the looped nature of the chromosomes is still evident in most cases.
Fig. 24. Sporocyte showing the delicate connections between the chromosomes and the incipient spindle.
Fig. 25. Chromosomes in the spindle being drawn into the equatorial plane.
Fig. 26. Early stage of metakinesis showing the chromosomes dividing.
Fig. 27. Later stage of metakinesis showing most of the chromosomes divided.
Fig. 28. Daughter star of the first division.
Fig. 29. Daughter cells showing the more or less distinct chromatin masses in the nuclei.
Fig. 30. Mother star of the second division.
Fig. 31. Daughter star of the second division.
Fig. 32. Polar view of the twelve chromosomes of a daughter star of the second division.
Fig. 33. Normal tetrad within the old sporocyte wall still showing the more or less distinct daughter chromosomes.



Humphrey on "Stamens of Smilax."



Humphrey on "Stamens of Smilax."

ADDITIONS TO THE KNOWN ORTHOPTEROUS FAUNA OF OHIO.

W. J. Kostir.

The first attempt to catalog the known Orthoptera of Ohio was made by Charles S. Mead in 1904. His list was published in the Ohio Naturalist for March of that year. It was based upon the collection of Orthoptera of the Ohio State University and the results of his own collecting in several parts of the state. The list contained nearly one hundred names. No additions to this list have been published up to the present time.

At intervals during the past three years the writer has collected in various parts of the state, and has also examined all the private and college collections of Orthoptera that were available. The literature has been carefully gone over for possible Ohio records, though little information was obtained in this way. Much help was received through the kind co-operation of numerous friends, and for this the writer wishes here to express his deep obligation. As a result of this work the species and varieties listed below have been added to the known Orthopterous fauna of Ohio. Much has also been learned about the distribution within the state of many of the other forms, and this information the writer hopes to incorporate in a short descriptive catalog of Ohio Orthoptera, upon which he is at present working.

Records of exotic species taken in the state have not been included in this list, except in cases where they seem to have become established.

Acknowledgment should here be made of assistance in identification kindly given by Mr. A. N. Caudell, Prof. A. P. Morse, and Mr. Morgan Hebard. Except where otherwise noted, all identifications have been made or verified by the writer.

Family FORFICULIDAE.

Vostox (Spongiphora) **brunneipennis** Serv.

One ♂, taken by Mr. Charles Dury at Cincinnati.

Family BLATTIDAE

Ischnoptera borealis Brunn.

All but one of the specimens referred by Mead to I. uhleriana belong to I. borealis. This one exception is the only specimen of I. uhleriana from Ohio that the writer has seen. It is a typical ♂, and was taken at Vinton, Vinton County, by Prof. James S. Hine. I. borealis has been taken in various parts of the state.

Ischnoptera couloniana Sauss.

One ♀, taken by Prof. J. S. Hine at Hanging Rock, Lawrence County.

Ischnoptera (Temnopteryx) **deropeltiformis** Brunn.
One ♂, taken by Mr. F. W. Cowles at Sugar Grove, Fairfield County.

Ischnoptera johnsoni Rehn. (I. intricata Blatch.)
One ♀, taken at Castalia, Erie County, by Miss Blanche Howe.

Family MANTIDAE.

(?) **Paratenodera** (Tenodera) **sinensis** Sauss.
This species was introduced in Cincinnati about 1905 by Miss Annette Braun, the egg-masses having been brought from Philadelphia. Specimens were seen each summer for several years afterward. It has not been seen for the past three summers and may have died out.

Stagmomantis carolina Linn.
Numerous specimens of this common southern species have been taken in the southern part of the state. 1 ♀ was taken by Mr. M. M. McLeish, in Franklin County, just east of Columbus.

Family PHASMIDAE.

(?) **Diapheromera velii** Walsh.
Scudder, in his paper on the genus Diapheromera (Psyche, vol. IX, (1901), pp. 187-189), records this species as present in Ohio. Until Scudder's material can be examined, however, it would seem to be doubtful whether he did not have at hand specimens of the later-described Manomera blatchleyi Caudell, ♀s of which, according to Caudell, are scarcely separable from those of D. velii.

(?) **Manomera** (Bacunculus) **blatchleyi** Caud.
Numerous specimens, all ♀s, agreeing with the descriptions of the ♀ of both Manomera blatchleyi and Diapheromera velii, have been taken by the writer at Cedar Point in the past three summers. Since no ♂s were taken, certain identification is hardly possible, but as D. velii is a species of distinctly southern range, it is very probable that they belong to M. blatchleyi.

Family GRYLLIDAE.

Ellipes minutus Scudd.
The specimens referred by Mead to Tridactylus apicalis Say belong to this species. They were collected in Columbus. The writer has also taken this species at Cedar Point, Erie County, and at Sugar Grove, Fairfield County.

Myrmecophila pergandei Brun.
This interesting myrmecophilous species was taken by Mr. Dury in thick woodland, near Cincinnati. It was found in ant-nests which had been exposed by overturning logs and stones.

Nemobius bruneri Heb.

Several specimens, ♂ and ♀, taken by the writer among the pebbles and stones along the Olentangy River, Columbus. (Id. M. Hebard).

Gryllus pennsylvanicus arenaceus Blatch.

One ♀, collected by Mr. Mead at Cedar Point.

Gryllus pennsylvanicus firmus Scudd.

Four specimens, collected by the writer: One ♂, two ♀s, at Ironton, Lawrence County, and one ♀, at Sugar Grove.

Gryllus pennsylvanicus integer Scudd.

Two ♀s, taken by the writer at Cedar Point. (Id. A. N. Caudell).

Oecanthus exclamationis Dav.

A number of specimens have been taken by the writer at Cedar Point.

Hapithus (Apithes) **agitator** Uhl.

One ♂, taken by Prof. Herbert Osborn at Rupels Station, Ross County.

Orocharis saltator Uhl.

Taken by Prof. Osborn at Rupels Station, Ross County, and by Mr. Dury, at Cincinnati.

Family TETTIGONIIDAE (LOCUSTIDAE).

Amblycorypha uhleri Stal.

One ♂, taken by the writer at Hanging Rock, Lawrence. Co.

Neoconocephalus (Conocephalus) **triops** Linn.

One ♂, taken at Etna Junction, Lawrence County.

Orchelimum agile DeG.

Two ♂s, taken by the writer at Hanging Rock, Lawrence County. (Id. A. N. Caudell).

Orchelimum glaberrimum Burm.

Specimens taken by Mr. Dury at Cincinnati and by the writer at Cedar Point and Columbus.

Orchelimum gladiator Brun.

One ♀, taken by the writer at Cedar Point.

Camptonotus carolinensis Gerst.

One ♀, taken by Prof. Osborn at Rupels Station, Ross County.

Diestrammena marmorata Haan.

This interesting Ceuthophilus-like form was introduced into this country some years ago from Japan. Specimens have been taken in an empty dwelling at Clintonville, Franklin County and in a greenhouse at Springfield. In the latter place, at least, it seems to have established itself permanently.

Ceuthophilus ensifer Pack.

Two specimens are in the Ohio State University collection, one ♂ from Sugar Grove and one ♀ from Columbus.

Ceuthophilus gracilipes Hald.

One ♂, taken by Mr. Dury at Cincinnati, and one ♀, taken by Dr. Morrey at Chester Hill, Morgan County. (Id. A. N. Caudell).

Ceuthophilus heros Scudd.

One ♂, taken by Mr. C. J. Drake, at Tiffin, Seneca County, and several specimens, ♂s and ♀s, collected by the writer near Clyde, Sandusky County and at Rocky River, Cuyahoga County. (Id. A. N. Caudell).

Ceuthophilus neglectus Scudd.

Several specimens, ♂s and ♀s, taken by Mr. R. J. Sim, at Jefferson, Ashtabula County.

Ceuthophilus pallidipes Walk.

Two ♂s, one ♀, taken by Mr. R. J. Sim, at Jefferson.

Ceuthophilus tenebrarum Scudd.

In his paper on the North American Ceuthophili, (Proc. American Academy, vol. XXX (N. S. XXII) (1894), p. 72), Scudder says of this species: "Two ♂, two ♀, from Ohio are in the collection of Riley. (U. S. Nat. Mus.).

Family ACRIDIIDAE.

Neotettix femoratus Scudd.

One specimen of this southern species, a ♂, was taken by the writer near S. Bloomingville, Hocking County.

Acrydium (Tettix) **hancocki** Morse.

One ♂, taken by the writer at Ironton.

Tettigidea lateralis Say.

One ♂ and two ♀s of this southern form were taken by the writer at Ironton. A few fairly typical specimens from Hanging Rock, Sugar Grove and Columbus are in the University collection. A number of specimens taken in the southern half of the state are plainly more or less intermediate between T. lateralis and T. parvipennis, through a perfect connecting series between the two is lacking.

Trachyrhachis thomasi Caud. (Mestobregma cincta auct.)

Several specimens, ♂s and ♀s, have been taken by the writer at Ironton, and near S. Bloomingville, Hocking County. One ♀ was picked up on the University campus, Columbus.

Trimerotropis citrina Scudd.

Taken by Mr. Dury on sand bars along the Ohio River at Cincinnati, where it is common.

Schistocerca alutacea rubiginosa Harr.

One specimen, taken at Athens, Athens County. In the Ohio State University Collection.

Schistocerca damnifica Sauss.

Taken by Mr. Dury at Cincinnati and by the writer at Sugar Grove.

Melanoplus minor Scudd.

One ♂, two ♀s, taken by the writer near Newark, Licking County.

Melanoplus morsei Blatch.

Two ♀s, taken by Mr. B. B. Fulton and the writer near S. Bloomingville, Hocking County.

Melanoplus obovatipennis Blatch.

Numerous specimens, ♂s and ♀s, have been taken by the writer at Hanging Rock, Lawrence County, at Cincinnati, at Sugar Grove, and near S. Bloomingville, Hocking County.

Melanoplus punctulatus Scudd.

Two specimens of this arboreal grasshopper have been taken at Cedar Point in different years, by Miss E. D. Faville and Mr. J. L. King.

Melanoplus similis Morse.

One ♂, one ♀, taken at Vinton, Vinton County. In the Ohio State University collection. (Id. A. P. Morse).

Publications of the Ohio Biological Survey.

The writer has before him two botanical bulletins of great interest as relating to the flora and vegetation of Ohio. The bulletins are 2 and 3 of the Ohio Biological Survey.

Bulletin 2, a "Catalog of Ohio Vascular Plants," by Prof. J. H. Schaffner, is a well-printed pamphlet of 120 pages, containing entries for 2065 species and a number of varieties and hybrids. The State Herbarium has been taken as the basis for the citation of species, although certain other reliable sources have been drawn upon. The list is a conservative one, quite a large number of species noted in former lists having been dropped. a thorough investigation having failed to show their occurrence in the state. The method of entry for such species is: Serial number, scientific name, common name, and distribution by counties. If the distribution is general the names of the counties are omitted, the occurrence being indicated as "General," "Rather general," etc.

The nomenclature used is that of Britton & Brown's Illustrated Flora, second edition, the sequence of species following strictly the author's phyletic classification. With reference to *Tipularia unifolia* we would suggest that reference should have been made to its occurrence in Ashtabula County as discovered in 1911 by R. J. Sim. (Torreya 12:107-110. May, 1912.

Bulletin 3, "A Botanical Survey of the Sugar Grove Region," by Prof. Robert F. Griggs, is an excellent treatment of the ecological relations of the vegetation of the "Sugar Grove region," a rolling upland cut up with numerous deep ravines, and extending in a north and south direction for about twenty miles in Fairfield and Hocking counties, south central Ohio. The region is immediately south of the glaciated region and may be considered as an outlier of the Appalachian Plateau.

To one familiar with the vegetation of the Appalachian Plateau in western Pennsylvania the Botanical Survey of the Sugar Grove Region reads almost like a survey of some of the quite similar areas to be found in the first-named region. The less important place occupied in the Sugar Grove Region by *Rhododendron*, *Kalmia latifolia*, *Castanea* and *Robinia Pseudacacia* and the absence of *Pinus Strobus* and *Azalea nudiflora*, is balanced by the presence of *Hypericum Drummondii*, *Napaea dioica* and the greater prominence of *Oxydendrum*, *Acer Negundo*, *Sullivantia*, *Quercus macrocarpa*, *Dodecatheon*, *Diospyros*, etc. Altogether the associations could be applied almost as well in the one region as in the other, but with the eastern species thinning out westward and a number of more northern species reaching into the Sugar Grove Region. Prof. Griggs is to be complimented upon the excellent manner in which he has accomplished this survey. It is to be regretted very much, however, that the proof-reading was not more carefully done. In a rather causal examination errors were noted in the scientific names to the number of sixty-six; on page 280, six out of twenty-seven names in one list being incorrectly spelled. We sincerely hope that more attention may be paid to the proof-reading in the future numbers of the survey, the present numbers being otherwise printed in a highly satisfactory manner.

O. E. Jennings.

Carnegie Museum, October 9, 1914.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, March 2, 1914.

The meeting was called to order at 7:30 by the President, Mr. Kostir; the minutes of the previous meeting were read and approved.

C. J. Reed, R. R. Robinson and Percy Wiltberger were elected to membership. The First paper of the evening was by Prof. A. P. Weiss on "the Nature of Inhibition as a Nervous Function."

The paper considered a way in which the modification which occurs in all human instinctive reflexes as maturity is reached, could be explained by assuming that a nervous current may deflect a weaker one and thus bring about a combination of reflexes not present at birth, but which results in characteristically adult behavior. In this paper, inhibition (usually described as a checking or blocking mechanism) is considered as being a condition in which one nervous process deflects another and thus brings about a modification of the original response.

The next part of the program was a symposium on "The Determination of Sex." Prof. Schaffner talked on sex determination as demonstrated in plants. In some plants the sex can be changed; Equisetum for example, in which both gametophytes are produced from spores that look to be identical. In the higher plants the sex has been determined before reduction takes place.

Miss Ickes explained the chromosome theory of sex determination. According to this theory there is an accessory chromosome, the presence or absence of which determines the sex. Guyer found the accessory chromosome in guinea fowls, in chickens and in man. Nematodes and insects show the accessory chromosome.

Prof. Barrows gave a short report of Dr. Riddle's work with Dr. Whitman's pigeons. If the eggs are taken away as soon as laid and a long series of eggs obtained, those at the beginning of the series will produce males while those toward the end of the series will produce females. In the middle of the series the individuals show graded psychological attributes.

The meeting then adjourned.

Blanche McAvoy, Secy.

The twenty-fourth annual meeting of the Ohio Academy of Science will be held on November 26–28, at The Ohio State University, Columbus.

Date of Publication, November 5, 1914.

DECEMBER,
Volume XV. 1914 Number 2.

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TABLE OF CONTENTS.

THE INSECT GALLS OF CEDAR POINT AND VICINITY.

PAUL B. SEARS.
(Department of Botany, University of Nebraska.)

The following list is based on rather careful collections made during the summer of 1914. Since the list contains many forms common throughout Ohio, I have aimed to make the synonymy fairly complete to date, as an aid to students, while the bibliography has been limited to original description (where possible) and some more recent notice which should be helpful.

In the course of this work I have become deeply indebted to Mr. W. J. Kostir, of Ohio State University, while Prof. Herbert Osborn, Prof. B. W. Wells, Prof. Myron Swenk, Miss Edith Patch, Mr. Nathan Banks and others have shown me various kindnesses.

Figure 1. **Salix longifolia** affected by the mite **Eriophyes aenigma.** Walsh.

Cecidomyia salicis-aenigma Walsh.
Acarus salicis-aenigma Walsh. Proc. Ent. Soc. Phil. III:608.
Stebbins, Bull. 2 Springfield Museum: 10.

Terminal bud-gall, made up of an irregular cluster of yarn-like masses, each about 1-2 mm. in diameter, the whole 2 x 3 cm. Whitish tomentose, turning brown and remaining in situ. July. Fairly common.

Fig. 2. **Salix longifolia** affected by the mite **Eriophyes salicicola** Garman.

Phytoptus salicola Garman. 12th Rep. Ills. Ent. X.
Cook, Ins. Galls Ind.:862.

Leaf-gall, tiny, globular to irregular, often massed, on either surface of leaf, at times projecting through. .25–3 mm. across. Light green to completely crimson. July. Common.

Fig. 3. **Salix longifolia** affected by the gall-gnat **Rhabdophaga brassicoides** Walsh.

Cecidomyia salicis-brassicoides Walsh. Proc. Ent. Soc. Phil. III:577.
Cecidomyia brassicoides Beutenmueller.
Stebbins, Bull. 2 Springfield Museum:11.

Twig-gall, evident as telescoping of terminal twig-structures, with abnormal down-production, and great broadening of leaves, whole extending back 10 cm. or more. Frequent.

Fig. 4. **Salix longifolia** affected by the gall-gnat **Rhabdophaga strobiloides** O. S.

Cecidomyia strobiloides Osten Sacken, Mon. N. A. Dipt. pt. 1:203.
Cecidomyia salicis-strobiloides Walsh.
Stebbins, Bull. 2, Springfield Mus.:11.

Terminal bud-gall, showing as a rounded conical mass of closely appressed scale-like leaves. Green, with a whitish silky covering. 2.5–3 x 4 cm. Usually abundant, but scarce this year.

Fig. 5. **Salix** sp. affected by a saw-fly, probably **Cryptocampus nodus** Walsh.

Euura salicis-nodus Walsh. Proc. Ent. Soc. Phil. VI:253.
Cryptocampus salicis-nodus Rohwer.
Stebbins, Bull. 2, Springfield Mus.:12.

Twig-gall, being a spindle-shaped enlargement of the herbaceous or young woody twigs, concentric with the stem as a rule, about 1 cm. in diameter, and ranging up to 3.5 cm. in length. Color that of normal twig.

Fig. 6. **Salix longifolia** affected by the saw-fly **Pontania pomum** Walsh.

Nematus salicis-pomum Walsh. Proc. Ent. Soc. Phil. VI:255.
Nematus pomum Beut.
Cook, Appendix to Ins. Galls Ind.:5.

Leaf-gall, spherical to spherical constricted, on lower surface, and projecting slightly through. 5–10 mm. diameter. Color ranging from light green to red, depending upon light relation. Minute cork-specks frequently present. Very common. July 1st.

Fig. 7. **Salix longifolia** affected by the saw-fly **Pontania desmidoides** Walsh.

Nematus salicis-desmidoides Walsh. Proc. Ent. Soc. Phil. VI:257.
Nematus inquilinus Walsh.
Pontania inquilina Marlatt.
Cook, App. Ins. Galls Ind.:5.

Leaf-gall, flattened bean-shaped, bisected by leaf, usually centered on a lateral vein, one to several galls on a leaf. 5–8 mm. long, 4–5 mm. broad and thick. Color various, usually crimson. Abundant in a restricted area. July 23.

Fig. 8. **Populus deltoides** affected by the louse **Pemphigus populicaulis** Fitch.

Byrsocrypta populicaulis Walsh.
Fitch, Rep. N. Y. Ent. V:845.
Cook, Ins. Galls Ind.:849.

Dome-shaped gall at junction of leaf and petiole, the opening at base of dome being a spiral slit caused by the complete curving of the petiole on itself. 5–10 x 10–15 mm. Color normal, with gray flecks of cork. Very common. July.

Fig. 9. **Populus deltoides** affected by the louse **Pemphigus populitransversus** Riley, Bull. U. S. Geol. Surv. V:15.

Cook, Ins. Galls Ind.:850.

Petiole gall, being a spherical, subspherical, or spindle-shaped enlargement, rarely involving base of leaf, and developing a small transverse median slit for emergence of the liee. 8–12 mm. diameter, color being that of normal petiole. July. Very common.

Fig. 10. **Populus deltoides** affected by the louse **Pemphigus vagabundus** Walsh.

Byrsocrypta vagabunda Walsh. Proc. Ent. Soc. Phil. I:306.
Cook, Ins. Galls Ind.:850.

Terminal bud-gall of leathery texture, flatly saccate, but very irregularly lobed and branched, developing labiate openings at peripheral points for emergence of parasites. Size varies greatly up to 1 dm. in diameter. Color light yellow-green, with tinges of red, rapidly discoloring on maturity. July 1. Very common.

Fig. 11. **Betula** sp. affected by the mite **Eriophyes brevitarsus** Focksu (?), Rev. Biol. Nord. France III:3.

Banks, Cat. N. A. Acarinae.

Tiny pouch-gall, irregularly scattered over leaf, and opening on under surface. .5–1. mm. diameter. Green, rapidly discoloring.

Fig. 12. **Betula** sp. affected by the louse **Hamamelistes spinosus** Shimer.

Hormaphis papyraceae Oestlund.
Shimer, Trans. Am. Soc. I:284.
Patch, Bull. 220, Me. Ag. Exp. Sta.:279.

Leaf-gall, being a fold along the lateral veins, opening on under side of leaf, which is often seriously deformed by the presence of one or more such galls. Fold filled with white flocculent excreta. This louse is found on the witch hazel an alternate host, hence the generic name of the insect.

Fig. 13. **Hicoria ovata** affected by an unknown gall-gnat.

Leaf-gall on under surface, having the form of a stout inverted cone, attached by its apex, and with the free base surrounded by a conspicuous fringe. 3–4 mm. high, 4–5 mm. in diameter. Green to light yellow-green. Huron, July 25. Quite rare, and, I believe, hitherto unreported.

Fig. 14. **Hicoria ovata** affected by an undetermined gall-gnat, doubtless the same figured by Miss Stebbins as **Cecidomyia caryaecola,** Bull. 2, Springfield Mus. :13, 70.

Leaf-gall, conical, on underside, with a sharply pointed tip, which is elongated and curved as a rule. The broad base, as gall matures, developes a thin wide flange parallel and close to plane of leaf. 4 x 5 mm. Common at Huron in late July.

Fig. 15. **Hicoria ovata** affected by the gall-gnat **Caryomyia persicoides** O. S.

Cecidomyia persicoides Osten Sacken, Mon. Dipt. N. Am. pt. 1:193.
Felt, Journ. Sc. Ent. IV:456.

Globular leaf-gall, on lower surface, along mid-vein, and heavily covered with silken down, "like that of a peach and looking like a very diminutive fruit of this kind." (Beutenmueller). 2–4 mm. diameter. Light brown. Huron, late July. Common.

Fig. 16. **Hicoria ovata** affected by the gall-gnat **Caryomia holotricha** O. S.

Cecidomyia holotricha Osten Sacken, Mon. Dipt. N. Am. pt. 1:193.
Felt, Journ. Ec. Ent. IV:456.

Leaf-gall, on underside, sub-globular, papillate on flattened free end, and finely pubescent over all. Single-chambered. About 4 mm. diameter. Yellow-green to red-brown.

Fig. 17. **Hicoria glabra** affected by the gall-gnat **Caryomyia caryaecola** O. S.

Cecidomyia Caryaecola Osten Sacken, Mon. Dipt. N. Am. pt. 1:192.
Felt, Journ. Ec. Ent. IV:456.

Leaf-gall, smooth, conical, attached to under surface of leaf by rounded base, and lying close to veins. "Onion-shaped"—Beutm.; "elongate onion-shaped,"—Ost. Sack. 5x3 mm. Thin-shelled, glaucous green, becoming brown and brittle in August. Huron, late July. Common.

Fig. 18. **Hicoria glabra** affected by the gall-gnat **Caryomia inanis** Felt.

Felt, Journ. Ec. Ent. IV:456.

Leaf-gall, on upper surface, globular flattened with terminal nipple, and false chamber at free end. Thin-shelled, green, rapidly discoloring. 4 x 3 mm. Huron, late July. Common.

Fig. 19. **Hicoria ovata** affected by the gall-gnat **Caryomyia tubicola** O. S.

Cecidomyia tubicola Osten Sacken, Mon. Dipt. N. Am. pt. 1:192.
Felt, Journ. Ec. Ent. IV:456.

Leaf-gall, on underside. Cylindrical, set in a socket from which it readily detaches. 1.5 x 6 mm. Light green to red. Fairly common. Huron, late July.

Fig. 20. **Quercus velutina** affected by the gall-gnat **Cecidomyia oruca** Walsh (?) in company with an undetermined mite.

Felt, Journ. Ec. Ent. IV:467.

Leaf-gall, evident as a fold snug alongside veins on under surface. Pouches isolated at times, but usually confluent and present in great numbers. Brownish opening on upper surface, resembling swollen lips of a knife-cut. In southern Ohio I have seen every leaf on a good-sized tree dying from this gall, as early as June. (The figure shows what are doubtless galls of **Cecidomyia foliora** Russ. & Hook., evident as infoldings of the edge.)

Fig. 21. **Quercus imbricaria** affected by the gall-wasp **Andricus futilis** O. S.

Cynips futilis Osten Sacken, Proc. Ent. Soc. Phil. I:63.
Andricus (Callirhytis) futilis Bassett.
Beutenmueller, Bull. Am. Mus. IV, No. 1:254.

Leaf-gall, woody, flattened spherical, resembling a wart on the upper surface and showing as a slight, nippled projection on lower surface. Usually present in great numbers, on both Q. imbricaria and Q. velutina. 2–4 mm. diameter, often confluent. Dark brown. Quite common. July-August.

Fig. 22. **Quercus imbricaria** affected by the gall-wasp **Andricus singularis** Bassett.

Cynips quercus-singularis Bassett, Proc. Ent. Soc. Phil. II:326.
Cynips singularis O. S.
Cook, Appendix Ins. Galls. Ind., p. 3.

Leaf-gall, globular, about 18 mm. diameter and showing greater part of its bulk on under surface of leaf. Larval chamber, 2–3 mm. diameter, is supported in center by slender branching filaments, radiating in all directions. Light brown and papery when old. June 25. Fairly common.

Fig. 23. **Quercus alba** affected by the gall-wasp **Andricus clavula** Bassett.

Cynips arbor Fitch.
Cynips clavula Bassett, Proc. Ent. Soc. Phil. III:686.
Andricus (Callirhytis) clavula Bassett.
Beutenmüller, Bull. Am. Mus. IV, No. 1:255.

Twig-gall, being a club-shaped swelling of the extreme tip. 1.5 x 2–3 cm. Green, single-chambered, becoming woody and dark after emergence of insect in midsummer. Surface often corrugated and covered with cork spots. Cedar Point and Huron. Common.

Fig. 24. **Quercus imbricaria** affected by the gall-wasp **Amphibolips nubilipennis** Harris.

Cynips nubilipennis Harris, Rep. Ins. Mass. Inj. Veg. 1841:399.
Callaspidea nubilipennis Fitch.
Cynips quercus sculptus Bassett.
C. quercus sculpta Walsh.
Amphibolips sculpta Mayr.
Beutenmuller, Bull. Am. Mus. XXVI.

Leaf-gall, globular, succulent, translucent, "about 12–20 mm. in diameter and has a very striking resemblance to a large white grape," (Beutm.) Not common.

Fig. 25. **Quercus rubra** affected by the gall-wasp **Amphibolips confluens**—form **spongifica** O. S.

Cynips confluens Osten Sacken, Proc. Ent. Soc. Phil. I:56.
C. quercus coccinea O. S.
Amphibolips coccinae Ashmead.
C. Q. spongifica O. S. (and Riley later).
Amphibolips spongifica Reinhard.
Amphibolips confluentus Beutenmuller, Bull. Am. Mus. XXVI.

Leaf-gall, globular, suppressing part or all of leaf, at first green, soon becoming light brown, with shiny, papery wall, containing a spongy mass of radiating fibres covered with down, which hold in place the oblong central larval chamber. 3–5 cm. in diameter. Common at Huron. This insect shows an alternation of generations, hence the long list of synonyms.

Fig. 26. **Quercus macrocarpa** affected by the gall-wasp **Holcaspis mamma** Walsh.

Cynips q. mamma Walsh, Am. Ent. I:102.
Holcaspis duricoria Mayr.
Cynips duricaria Packard.
Holcaspis duricaria Beutenm.
Diplolepis q. macrocarpa Karsch.
Cynips macrocarpae Dalla Torre.
Andricus macrocarpae Dalla Torre and Kieffer.
Beutenmuller, Bull. Am. Mus. XXVI:31.

Twig gall, acorn-like, globular to elongate, with prominent conical projections at end. Single larval chamber in center of a brown, woody mass. Diameters variable, 5–12 mm. Common at Huron late in July.

Fig. 27. **Quercus imbricaria** affected by the gall-wasp **Holcaspis globulus** Fitch.

Callaspidea globulus Fitch, 5th Rep. Nox. Ins. N. Y. 1858:811.
Cynips globulus O. S.
Beutenmuller, Bull. Am. Mus. XXVI.

Twig gall, spherical, 5–15 mm. diameter, usually in clusters. Yellow and pink-flushed, tough in texture when young, brown and corky when old. Common in Huron. July.

Fig. 28. **Quercus macrocarpa** affected by the gall-wasp **Neuroterus floccosus** Bassett.

Cynips floccosa Bassett, Can. Ent. XIII:111.
Neuroterus exiguissima Bassett.
N. exiguissimus Dalla Torre and Kieffer.
Beutenmüller, Bull. Am. Mus. XXVIII:123.

Leaf gall, single-chambered, evident as a yellow-green blister on upper surface, and especially as a circular, convex, rust-colored patch of pubescence on lower surface. 3–4 mm. diameter. Common. Huron, late July.

Fig. 29. **Ulmus racemosa** affected by the mite **Eriophyes ulmi** Garman.

Phytoptus ulmi Garman, 12th Rep. Ills. State Ent. 1882.
Cook, Ins. Galls Ind. 861.

Leaf gall on upper surface, showing as a tiny spherical pouch with narrow constricted neck. Green Island, July 20. Uncommon.

Fig. 30. **Ulmus americana** affected by the louse **Colopha ulmicola** Fitch.

Byrsocrypta ulmicola Fitch, 5th Rep. Nox. Ins. N. Y. 1858:843.
Thelaxes ulmicola Walsh.
Pemphigus ulmicola Packard.
Glyphina ulmicola Thomas.
Colopha compressa Koch.
Colopha eragrostis Middleton.
Patch, Bull. 181 Me. Ag. Exp. Sta. 196.

Leaf gall on upper surface, of the well-known cock's-comb type, being an elongated pouch or fold, dorsally crested. 10–30 mm. long x 5–10 mm. high. Green, soon discoloring.

Fig. 31. **Ulmus americana** affected by the louse **Schizoneura lanigera** Riley.

Schizoneura americana Riley in part.
Patch, Bulls. 203 and 217 Me. Ag. Exp. Sta.

Leaf gall, being a worm-like inrolling of the edge toward the under side, quite variable in size. Found empty in midsummer, and hence assumed to be caused by S. lanigera, which, as Miss Patch has found, differs from S. americana in migrating to the apple after the spring brood has formed galls on the elm.

Fig. 32. **Celtis occidentalis** affected by a mite **Eriophyes** sp.

Phytoptus sp. with fungus *Sphaerotheca phytoptophila* Kell et al. Kan. Ag. Exp. Sta. Rep. 1888:302.
Cook, Ins. Galls Ind. 862.

"Witch-broom" gall, evident as a multiplication of twigs from a single source, accompanied by profusion of buds which often telescope and abort, giving base of tuft a scaly appearance. Confined mainly to smaller branches, less than ½ in. diameter. Common. The fungus which formerly shared blame with the insect is now thought by many to be merely a secondary and incidental affair, the real culprit being the mite.

Fig. 33. **Celtis occidentalis** affected by a gall-gnat, undetermined.

Leaf gall, on under side, stoutly conical and nippled at tip. Succulent, pale green, and covered with fine bloom when young. 3 x 4 mm. Present in great numbers. Larva white.

Fig. 34. **Celtis occidentalis** affected by a gall-gnat, undetermined.

Stoutly acorn-shaped gall, crowded along sides of green twig and on either surface of leaf. Lower third ridged, whole finely bristled, light green and 3–6 mm. diameter. Very abundant. Larva light orange.

Fig. 35. **Celtis occidentalis** affected by a gall-gnat, undetermined.

Leaf gall, present in great numbers on underside. A "peg-shaped" gall, cylindrical when young, and developing a thickened base as it grows. Pale green, stragglingly hirsute, 2–3 mm. long. Very common. Larva red.

Fig. 36. **Celtis occidentalis** affected by the gall-gnat, **Cecidomyia unguicula** Beutenm.

Beutenmuller, Bull. Am. Mus. XXIII:388.

Leaf gall of unmistakable "carpet-tack" form, usually found on lower surface. Tip breaks off clean for emergence of insect. Green to straw-color, 1.5–4 x 3–5 mm. Quite abundant, often in company of one or more of the three preceding forms.

Fig. 37. **Celtis occidentalis** affected by the psyllid **Pachypsylla celtidis-gemmae** Riley.

Riley, 5th Rep. U. S. Ent. Com. 618.
Beutenmuller, Bull. Am. Mus. IV, No. 1:275.

Bud gall, being a rounded swelling and deformation of woody consistency and about 5–10 mm. diameter. Rare.

Fig. 38. **Celtis occidentalis** affected by the psyllid **Pachypsylla celtidis-mamma** Riley.

Riley, Johnson's Univ. Encyc. 1876.
Cook, Ins. Galls Ind. 844.

Leaf gall, evident as a pit in upper surface, and as a subspherical gall with constricted base on lower surface. Green-glaucous, often brown-mottled. 3–5 x 4–6 mm. Abundant. June-July.

Fig. 39. **Rosa** sp. affected by the gall-wasp **Rhodites rosaefolii** Cockerell.

Rhodites lenticularis Bassett.
Cockerell, Ent. M. Mag. XXV:324.
Beutenmuller, Bull. Am. Mus. XXIII:646.

Leaf gall, convex discoidal, projecting from both surfaces. White and fairly hard. .5 x 4–5 mm. Common in July.

Fig. 40. **Rosa sp.** affected by the gall-wasp **Rhodites nebulosus** Bassett.

Lytorhodites nebulosus Kieffer.
Bassett, Trans. Am. Ent. Soc. XVIII:63.
Beutenmüller, Bull. Am. Mus. XXIII:644.

Leaf gall on under side, globular, light green to golden brown, and covered with short spines. Diameter 5–8 mm. Castalia, July. Rather scarce.

Fig. 41. **Rubus nigrobaccus** affected by the gall-wasp **Diastrophus nebulosus** O. S.

Osten Sacken, Proc. Ent. Soc. Phil. II:36.
Stebbins, Bull. 2, Springfield Mus. 36.

"Cane gall," being an irregular swelling of varying length (5–8 cm.) and showing several longitudinal ridges, each forming the abode of an individual larva. Occasional at Castalia.

Fig. 42. **Prunus serotina** affected by the mite **Eriophyes serotinae** Beutenm.

Acarus serotinae Beutenmuller, Bull. Am. Mus. IV:278.
Stebbins, Bull. 2, Springfield Mus. 40.

Leaf gall, usually on upper surface, showing as a small pouch with long, slender neck, opening below. 5–10 mm. long, 1–3 mm. wide, leaf-green to rose. Chalcid inquilines are frequently present.

Fig. 43. **Prunus virginiana** affected by a mite, **Eriophyes sp.** The gall is very like the preceding, undergoing a simultaneous cycle, but is very much smaller, 1–2 mm. in length. Either the well-known chemical differences of the two kinds of leaves cause them to respond differently to the attacks of the same species of mite, or what is more probable, two species or varieties of mites are indicated.

Fig. 44. **Prunus virginiana** affected by the gall-gnat **Contrinia virginiana** Felt.

Cecidomyia virginiana Felt.

Flower of fruit gall, evident as an abnormal swelling of the green fruit. On June 29, when normal fruits were 4–5 mm. diameter, galled specimens were 7-10 mm. and of a sickly yellow-green color. Quite common.

Fig. 45. **Gleditschia triacanthos** affected by the gall-gnat **Dasyneura gleditschiae** O. S.

Cecidomyia gleditschiae Osten Sacken, Proc. Ent. Soc. Phil. VI:219.
Felt, Journ. Ec. Ent. IV:461.

Pod-like gall, caused by the closure and subsequent distension of leaflets. Of varying size and extent within each leaflet. Frequently showing inquiline mites and aphids. Common.

Fig. 46. **Rhus toxicodendron** affected by the mite **Eriophyes rhois** Stebbins.

Phytoptus sp. Garman, 12th Rep. St. Ent. Ills. 138.
Eriophyes sp. Cook.
Stebbins, Bull. 2, Springfield Mus. 41.

Leaf gall on either surface made up of tiny bulges and occasional pouches, giving the leaf a granular appearance. The open side of the gall shows considerable down—or trichome-production. Very abundant.

Fig. 47. **Rhus aromatica** affected by a mite, **Eriophyes sp.**

Leaf gall, differing from preceding in always consisting of one pouch, or several fused, on upper surface of leaf. Usually red-tipped or entirely red, and about 1 x 3 mm. A form hitherto unreported, I believe.

Fig. 48. **Impatiens biflora** affected by the gall-gnat **Lasioptera impatientifolia** Felt.

Cecidomyia impatientis O. S. in part.
Felt, 22nd Rep. Ins. N. Y. 105.
Stebbins, Bull. 2, Springfield Mus. 43.

Leaf-gall, frequently involving stems or buds, sub-spherical, several chambered. 4-12 mm. diameter. Greenish translucent, becoming tinged with pink. Common.

Fig. 49. **Vitis vulpina** affected by the louse **Phylloxera vastatrix** (Fitch) Planchon.

Phylloxera vitifoliae Fitch, 1st Rep. Ins. N. Y. 158.
Pemphigus vitifoliae Fitch.
Brysocrypta vitifoliae Walsh.
Stebbins, Bull. 2, Springfield Mus. 44.

Leaf gall, present in great numbers on under side, and being very rough and irregularly spherical, usually bristle-tipped. Leaf-green, single-chambered and often showing inquiline arachnids and cecidomyid larvae. 2–5 mm. diameter. This is the louse so destructive to grapes in France, by virtue of its root-infesting proclivities. Frequent.

Fig. 50. **Vitis vulpina** affected by the gall-gnat **Schizomyia coryloides** Walsh & Riley.

Cecidomyia vitis-coryloides Walsh and Riley, Am. Ent. 1:106.
Stebbins, Bull. 2, Springfield Mus. 44.

Bud gall, being a spherical mass 15–50 mm. diameter, of small, lozenge-shaped galls, each about 5 x 15 mm. Leaf-green, covered with a felty yellow or orange pubescence. Infrequent.

Fig. 51. **Vitis vulpina** affected by the gall-gnat **Cecidomyia viticola.**

Cecidomyia viticola Osten Sacken. Mon. N. Am. Dipt. pt. 1:202.
Beutenmüller, Bull. Am. Mus. IV, pt. 1:272.

Leaf gall on lower surface, straight, conical, narrowly tapering. Light yellow-green, red or black tipped. 3–10 x 2 mm. Uncommon.

Fig. 52. **Vitis vulpina** affected by the gall-gnat **Schizomyia petiolicola** Felt.

Felt, Journ. Ec. Ent. IV:475.

Petiole gall, more or less elongated or spindle-shaped, and mainly on outer (lower) side of petiole. Color normal. 5–10 x 15–30 mm. Not common.

Fig. 53. **Tilia americana** affected by the mite **Eriophyes abnormis** Garman.

Phytoptus abnormis Garman, 12th Rep. Ills. St. Ent.
Cook, Ins. Galls Ind. 860.

Leaf gall, being a small pouch with constricted neck and fissured tip, usually on upper surface of leaf. Fairly common.

Fig. 54. **Tilia americana** affected by a gall-gnat (?), undetermined.

"Undetermined"—Wells, Oh. Nat. XIV, No. 6:294.

Bulbous enlargement of the petiole, more or less elongated, usually eccentric and near the base. Normal color, 5–8 mm. long, 2–3 mm. diameter. Seldom found.

Fig. 55. **Tilia americana** affected by the gall-gnat **Cecidomyia verrucicola** Osten Sacken, Can. Ent. VII:200.

Cook, Ins. Galls Ind. 838.

Leaf-gall, flattened, spherical, projecting about equally from both surfaces of leaf. Green and red, becoming brown when mature, and providing for emergence of insect by means of a hinged lid, which is usually below. Common.

Fig. 56. **Cornus stolonifera** affected by the gall-gnat **Cecidomyia** (?) **tuba** Stebbins.

Stebbins, Bull. 2, Springfield Mus. 46.

Leaf gall on underside, tubular, with swollen base and cleft tip, not unlike a kettle-spout. Bright red and finely pubescent like underside of leaf. 1–2 x 5–8 mm. Very rare.

Fig. 57. **Acer saccharum** affected by the mite **Eriophyes crumena** Riley.

Acarus aceris-crumena Riley, Am. Ent. II:339.
Phytoptus acericola Garman.
Eriophyes acericola Cook.
Stebbins, Bull. 2, Springfield Mus. 42.

Leaf gall, being a very slender, spindle-formed pouch on the upper surface. Green, rapidly discoloring. Abundant in a restricted area. .5 x 4–6 mm. Green Island. July.

Fig. 58. **Fraxinus americana** affected by the mite **Eriophyes fraxini** Garman.

Phytoptus fraxini Garman, 12th Rep. St. Ent. Ills.
Cook, Ins. Galls Ind. 862.

Leaf gall, hemispherical, projecting on upper surface and showing trichomatous (fuzzy) opening below. Heavily clustered. Green, later discoloring. 1–2 mm. diameter. Not common. Rye Beach, July 19.

Fig. 59. **Stachys aspera** affected by a gall-gnat, undetermined.

Bulbous stem enlargement, usually at base of petioles, which are often involved. Size various, 5–20 mm. diameter. Color normal. The gall is thoroughly tunneled by the orange larvae before they emerge. Common. Late July.

Fig. 60. **Teucrium canadense** affected by a gall-gnat, undetermined.

Stem gall of the same general character as the preceding, and like it, probably unreported. May be on main stem, petiole or peduncle, singly or in chains. 5–8 x 8–20 mm. Fairly common. July 22.

Fig. 61. **Cephalanthus cornutus** affected by the mite **Eriophyes cephalanthi** Cook.

(Identification by Mr. Nathan Banks).

Leaf gall of minute size, usually so abundant as to give leaf a granular appearance. Evident as small hemispherical projection from upper surface, open beneath and lined copiously with fine fuzzy (trichomatous) growth. Young leaves are frequently seriously deformed and stunted by these galls. Common. Mid-July.

Fig. 62. **Solidago canadensis** affected by the trypetid fly **Eurosta solidaginis** Fitch.

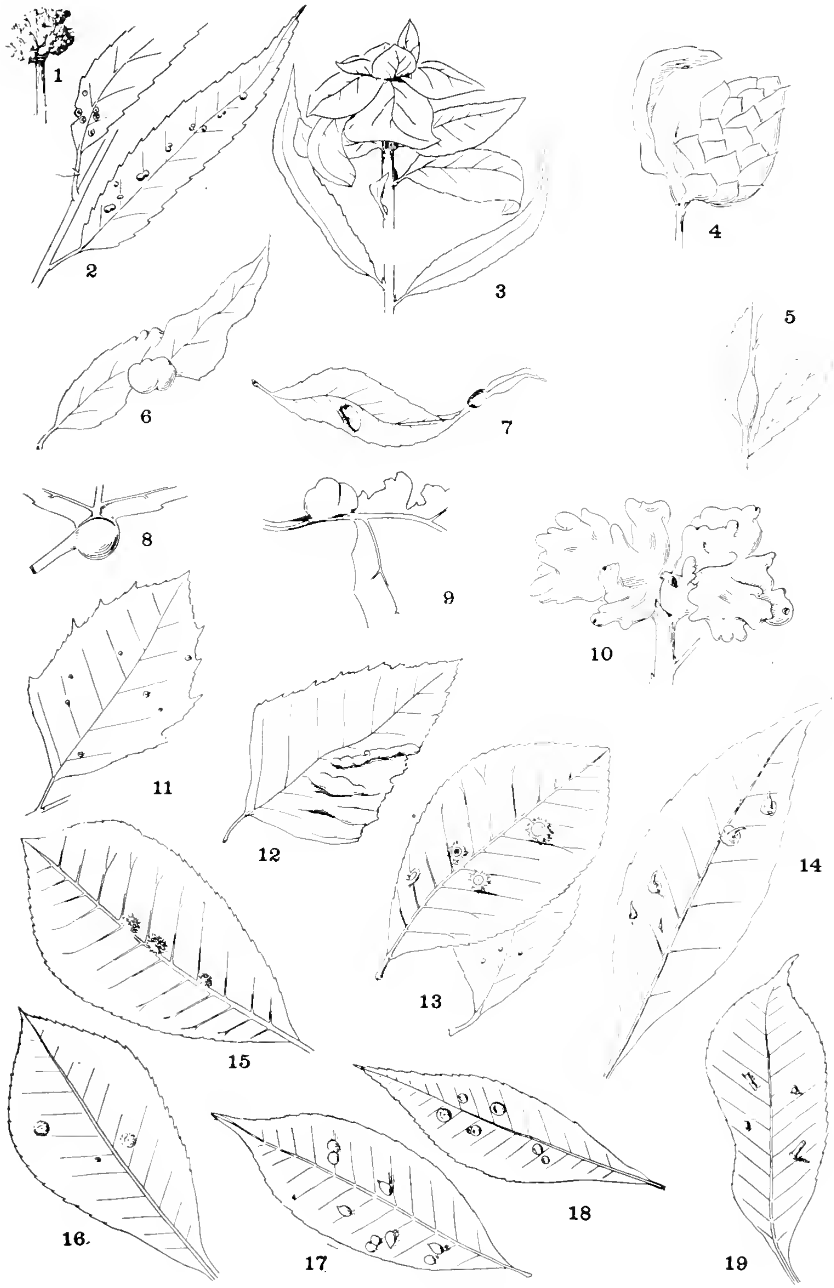
Acinia solidaginis Fitch, 1st Rep. Ins. N. Y. 771.
Tephritis asteris Harris.
Trypeta solidaginis Cook et al.
Stebbins, Bull. 2, Springfield Mus. 51.

Spherical stem gall, with a single central larval chamber, containing a maggot. Green, smooth, 2 cm. in diameter. Fairly abundant, especially at Huron.

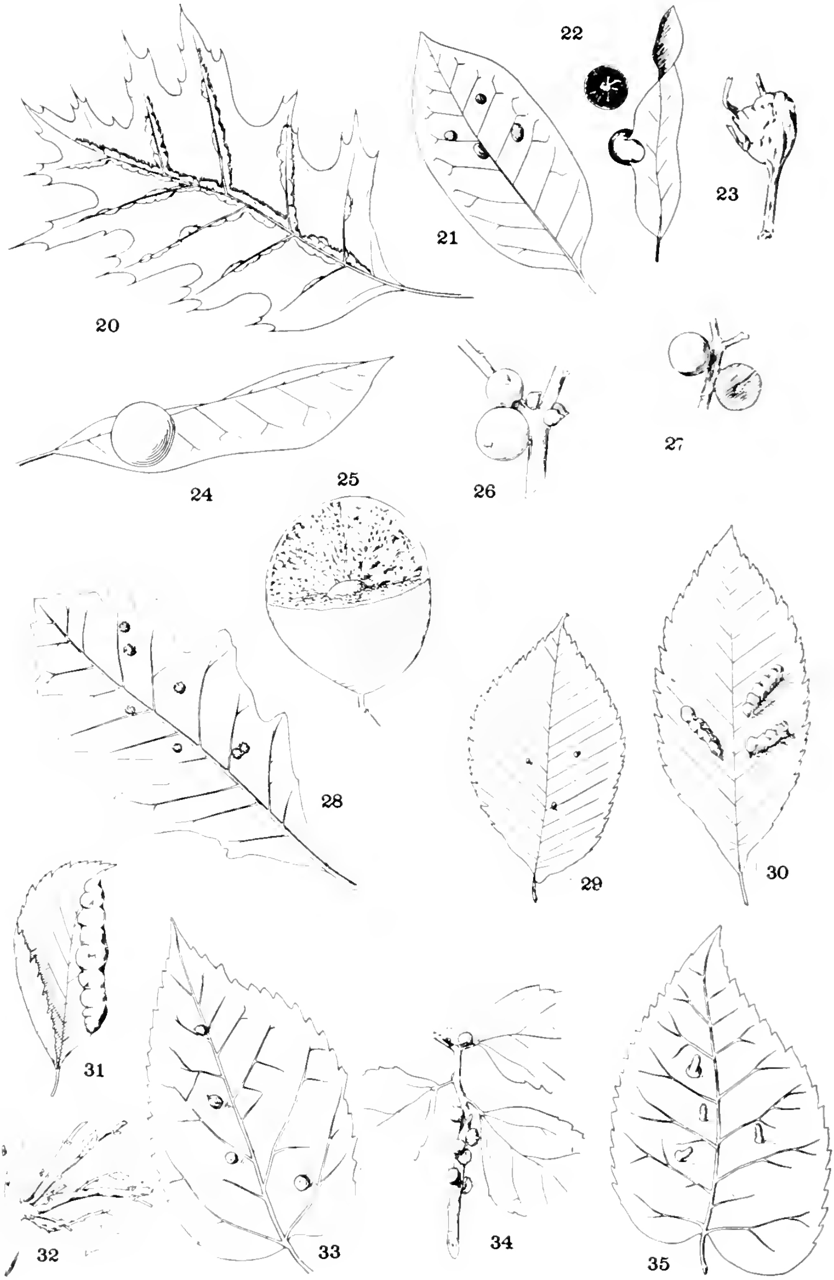
Fig. 63. **Solidago canadensis** affected by the moth **Gonorimoschema gallae-solidaginis** Riley.

Gelechia gallae-solidaginis Riley, 1st Rep. Ins. Mo. 173.
Stebbins, Bull. 2, Springfield Mus. 51.

Stem gall, being an elongate spherical to spindle-shaped swelling, normal color, containing single lepidopterous larva in large central chamber. 30–40 mm. long, and 10–20 mm. wide. Common.



Sears on Insect Galls.



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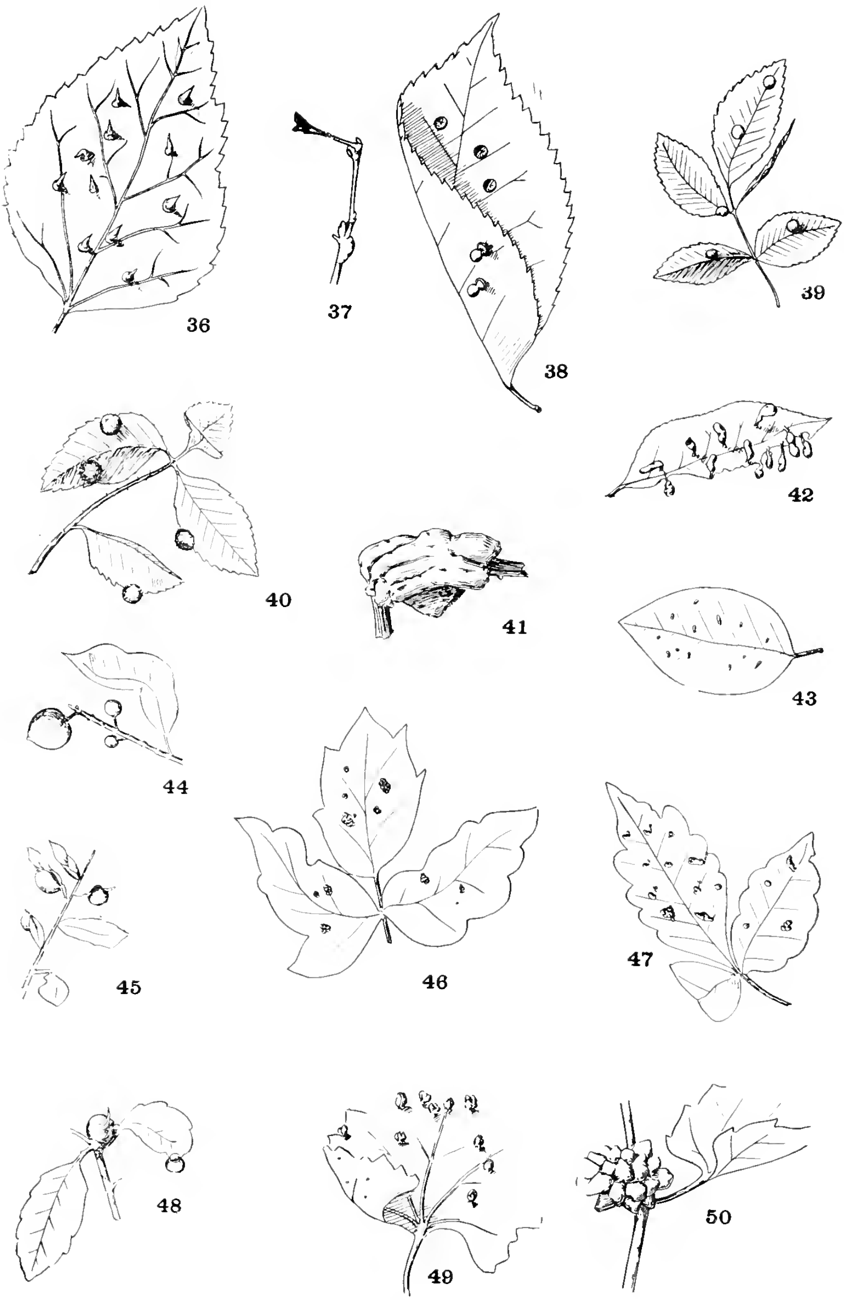

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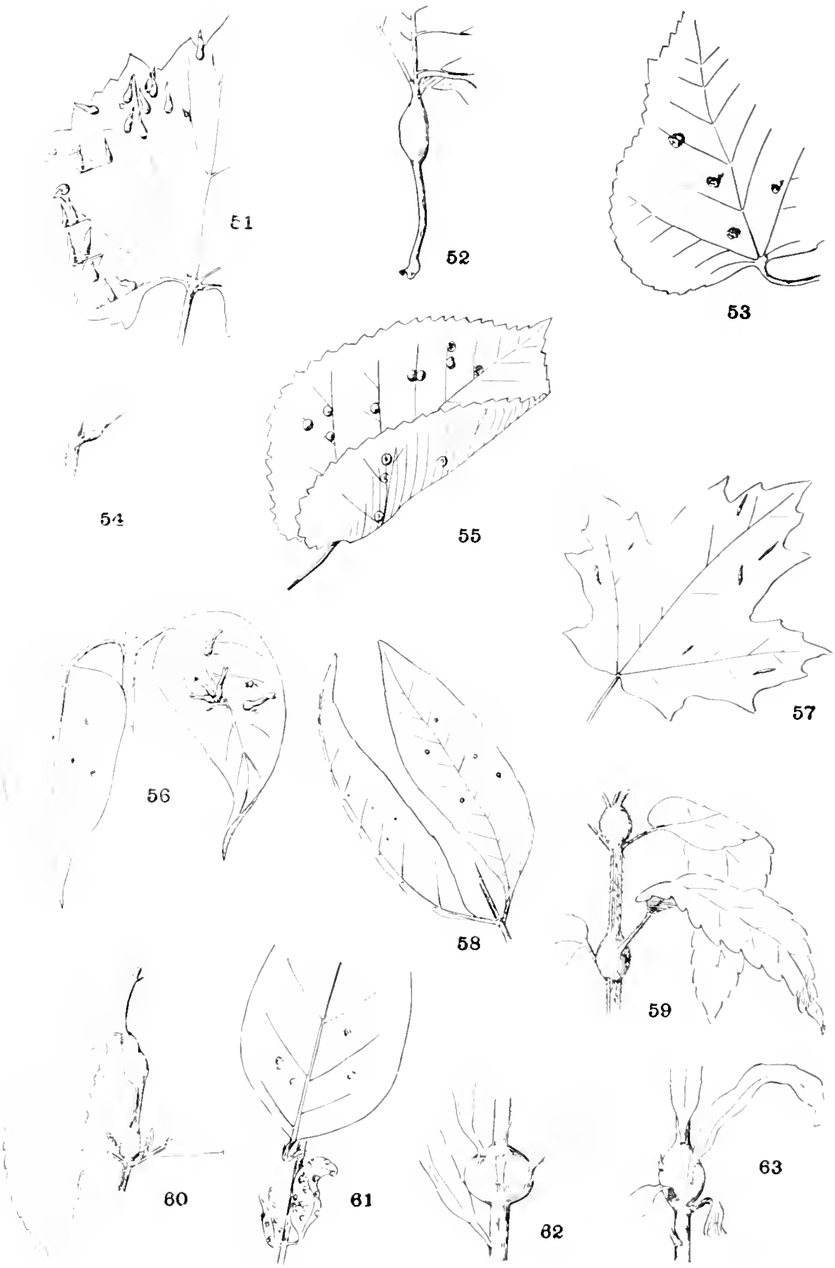

Scars on Insect Galls.

THE NATIVE AND CULTIVATED VICIEÆ AND PHASEOLEÆ OF OHIO.

GERTRUDE BARTLETT.

In the following study of the native, introduced and cultivated Vicieæ and Phaseoleæ of Ohio, an attempt has been made to find the most evident differences so that the species may be the most easily determined, and also to give a phyletic arrangement in so far as this is possible in plants so closely related.

The species of the Ohio State Herbarium were studied for characters and distribution, and most of the cultivated species were grown in the greenhouse, in order that definite data might be obtained, both of the vegetative parts and flowers. The actual measurements were taken from herbarium specimens and from the living plants and compared with those of Britton's Manual. The keys are based upon leaf, stem and flower characteristics present at the time of flowering. The habitat is usually given, also the distribution by Counties as represented in the Ohio State Herbarium. Economic notes and other miscellaneous facts are added, because of the great importance of these plants in agriculture and household economy.

FABATÆ, VICIEÆ AND PHASEOLEÆ.

Erect or trailing herbs, or climbing vines either twining or with tendrils, ours always herbaceous.

Leaves compound, pinnate or trifoliate, rarely reduced to one leaflet, alternate with stipules frequently having nectar glands. Leaves often ending in a simple or branched tendril, or in a short point. Roots with large or small tubercles. Flowers bisporangiate, hypogynous, pentacyclie pentamerous except the gynecium, zygomorphic, the two outer lower petals, more or less united forming a structure called the keel, which encloses the stamen column. Calyx of five united sepals, its lobes sometimes obscured. Stamens diadelphous, sometimes monadelphous. Carpel one with two lateral sutures, one of which is the placenta. Ovules one to many. Fruit a legume, dehiscent by two valves, often twisting spirally or indehiscent. Seeds with little or no endosperm. Cotyledons large and thick.

KEY TO THE TRIBES.

1. Leaves evenly pinnate with tendrils or bristles, or if odd-pinnate, then the stem 4-angled or with leaflets 9-25 and deeply serrate. Vicieæ.

1. Leaves odd-pinnate without tendrils, the leaflets not serrate and the stem round, or roundish, frequently twining. Phaseoleæ.

VICIEÆ.—Pea Tribe.

Herbs or vines erect or climbing by tendrils, usually glabrous and gray-green. Leaves pinnately compound, leaflets two to many; flowers axillary usually racemose though sometimes capitate or solitary; cotyledons remaining underground during the sprouting and growth of the seedling.

Many of the Vicieæ are cultivated for soiling, pasture, hay and seed.

Key to the Genera.

1. Leaves with terminal leaflet. 2.
1. Leaves ending in a tendril, spine or bristle; style usually more or less hairy. 3.
2. Peduncle one flowered, leaves serrate. *Cicer.* (1).
2. Peduncle two to several flowered, leaves not serrate. *Vicia* (2).
3. Stamen tube diagonal at the summit; style slender with a tuft of hairs or merely pubescence at the summit; veining of the leaves not prominent, veins pinnate. 4.
3. Stamen tube with a flat top; style flattened, bearded along the inner side; stipules usually large; veins on the under side of the leaf prominent; veins branched or parallel. 5.
4. Calyx lobes elongated; style flat; pod 2-seeded. *Ervum* (3).
4. Calyx lobes short; style threadlike; pod generally more than 2-seeded. *Vicia* (2).
5. Style without a groove; stipules mostly much smaller than the leaflets. *Lathyrus* (4).
5. Style grooved on the underside; stipules nearly as large or larger than the leaflets. *Pisum* (5).

1. **Cicer** L. Chick-pea.

Pubescent herbs or shrubs with evenly or odd pinnate leaves and more or less serrate leaflets. Flowers pedicelled, few or solitary, white to purple.

There are several species of Cicer, but only one has been generally introduced into the United States.

1. **Cicer arietinum** L. Chick-pea. An upright, very glandular pubescent annual, 9-20 in. high. Leaves odd-pinnate; leaflets 9-25, $\frac{1}{4}$-$\frac{1}{2}$ in. long, $\frac{1}{8}$-$\frac{1}{4}$ in. wide; stipules ovate-lanceolate, toothed Peduncle one flowered; flowers $\frac{1}{4}$-$\frac{1}{2}$ in. long, white to purple; pods very pubescent, 1-2 in. long; the seed light brown, angular, the micropylar point very prominent.

2. **Vicia** (Tourn.) L. Vetch.

Herbs or vines usually tendril-bearing, but sometimes with a terminal leaflet. Leaves nearly sessile evenly or odd-pinnate. Stipules sometimes with nectar glands. Flowers axillary, in twos or threes or racemose; style filiform, pod dehiscent, two to many seeded.

Key to the Species.

1. Stem erect, quadrangular. *Vicia faba* (1).
1. Stem climbing, weak or trailing. 2.
2. Peduncle very short or wanting, flowers 1 or 2, axilliary. 3.
2. Peduncle elongated, flowers racemed or spicate. 4.
3. Leaflets oblong, oval or obovate; stipules broad; flowers ½–¾ in. long, bluish purple. *Vicia sativa*. (8).
3. Leaflets except those of the lower leaves, linear or linear oblong. *Vicia angustifolia* (9).
4. Spikelike raceme, dense, secund, or one-sided, 15–40 flowered. 5.
4. Flowers in a loose raceme, not one-sided, 1–20 flowered. 6.
5. Stem, leaves and flowers villous pubescent; annual or biennial. Cultivated. *Vicia villosa*. (3).
5. Plant glabrous or very finely pubescent; perennial. *Vicia cracca*. (2).
6. Stipules rather broad, foliaceous, triangular ovate, sharply toothed. *Vicia americana*. (4).
6. Stipules linear or linear oblong, entire. 7.
7. Flowers 8–24; white, keel tipped with blue. *Vicia caroliniana*. (5).
7. Flowers 1–6; bluish purple. 8.
8. Calyx glabrous, ovules 3–6, flowers $\frac{1}{6}$ to $\frac{1}{4}$ in. long. *Vicia tetrasperma*. (6).
8. Calyx pubescent ovules 2; flowers $\frac{1}{8}$ in. long. *Vicia hirsuta* (7).

1. Vicia faba L. Horse Vetch. An erect cultivated annual with a green, more or less reddish, 4-angled stem, 2–6 ft. high and ⅓-¼ in. in diameter. Leaves with a terminal leaflet or bract; leaflets oval, 2 in. long, 1½ in. wide, stipules ½ in. broad, having prominent nectar glands. Flowers sessile, light-blue to purple; pods thick, broad, curved, pendent, the reddish brown seeds usually nearly circular, 1 inch broad, and the hilum ⅕ of the circumference. Some varieties resemble the common bean in shape.

Vicia Faba is the bean of Roman history. It was often used as a counter in their mathematical calculations. The cool, wet climate of England is well suited for its cultivation, and it is there used for the food of man as well as for horses and cattle. It is cultivated in Ohio as an ornamental plant and occasionally for food. The seeds are used green or dried, boiled or roasted. It is also called Horse Bean, Broad Bean, Broad Windsor, English Broad Bean and English Dwarf Bean.

2. Vicia cracca L. Cow Vetch. A weak trailing glabrous, or very finely pubescent perennial, 2–4 ft. long and $\frac{1}{16}$ in. in diameter. Leaflets 4–12 pairs, linear ⅔–⅚ in. long, $\frac{1}{12}$–⅙ in. wide, tendrils branched, the stipules linear, $\frac{1}{12}$–⅓ in. long. Flowers bluish-purple to white, ½ in. long, arranged in a dense, secund, 15–40 flowered raceme 1–4 in. long; pods ¾–1 in. long; seeds 3–8, round and velvety black.

It is generally found in dry soil. Columbiana, Wayne, Lake, Huron, Seneca, Cuyahoga. The Cow Vetch is also called Bird Vetch, Blue Vetch and Tufted Vetch.

3. Vicia villosa Roth. Hairy Vetch. A villous pubescent much branched, weak and trailing, cultivated annual, or biennial, with a stem 2-6 ft. long and $\frac{1}{16}$ in. in diameter. Leaflets 8–24, linear, $\frac{3}{8}$-$\frac{1}{2}$ in. long, $\frac{1}{8}$-$\frac{3}{16}$ in. wide, obtuse at the base, acute at the apex; tendrils branched. Peduncle shorter than, or equalling the leaves; the flowers purple to white; the pod $\frac{3}{4}$ to 1 in. long; $\frac{1}{6}$-$\frac{1}{4}$ in. wide; seed round and black.

The seed of Vicia villosa may be distinguished by the lemon-yellow beneath the outside coating from the Vicia sativa, which is an orange-yellow. Vicia villosa is able to withstand the northern climate, while Vicia sativa is often winter-killed, so the ability to distinguish the seed is of importance. The Hairy Vetch is being experimentally used by many farmers over Ohio, as a soiling and hay crop.

4. Vicia americana Muhl. American Vetch. A glabrous, or very finely pubescent weak trailing perennial, 2–3 ft. long and $\frac{1}{16}$ in. in diameter. Leaflets 1 in. long, $\frac{3}{8}$-$\frac{9}{16}$ in. wide, the tendrils branched, the stipules broad and foliaceous, or triangular-ovate and sharply toothed. Flowers in a loose raceme, with 1–20 flowers, blue to purple; pod glabrous, $\frac{1}{2}$–$\frac{3}{4}$ in. long, seeds 2–5.

It has been reported only from the northern part of the State. Cuyahoga, Geauga, Erie, Ottawa and Lucas. It is also called Purple Vetch.

5. Vicia caroliniana Walt. Carolina Vetch. A weak trailing glabrous perennial with the stem 1–2 ft. long and $\frac{1}{16}$ in. in diameter. Leaflets, 4–9 pairs, $\frac{5}{8}$-1 in. long, $\frac{1}{4}$-$\frac{3}{8}$ in. wide, the tendrils simple or compound the stipules linear or linear-oblong entire. Racemes loose, 8–20 flowered, with a white keel tipped with light blue, pod glabrous, $\frac{3}{4}$ in. long, $\frac{3}{16}$ in. wide, the seed round and brown.

Washington, Gallia, Lawrence, Jackson, Scioto, Ross, Pike, Darke, Williams, Lorain, Ottawa and Cuyahoga. It is also called Pale Vetch.

6. Vicia tetrasperma (L) Moench. Slender Vetch. A small trailing glabrous annual, the stem 6–24 in. long and $\frac{1}{16}$ in. in diameter. Leaflets 6-12, $\frac{3}{8}$ in. long, $\frac{1}{8}$ in. wide; the tendrils branched, the stipules linear or linear oblong, entire. Peduncle equalling or shorter than the leaves, raceme loose with 1–6 flowers, $\frac{1}{6}$-$\frac{1}{4}$ in. long, pale blue to purple; calyx glabrous, pod glabrous, $\frac{1}{2}$ in. long, the seeds 3–6, spherical, dark brown. Lake County.

7. Vicia hirsuta (L) Koch. Hirsute Vetch. A small glabrous or finely pubescent annual, 1–2 ft. long, the diameter of the stem $\frac{1}{16}$ in. Leaflets 8–16, $\frac{1}{2}$-$\frac{5}{8}$ in. long, $\frac{1}{16}$-$\frac{1}{8}$ in wide, linear or linear oblong, emarginate, the tendrils branched, the stipules linear. Flowers in a loose raceme with 1–6 flowers $\frac{1}{8}$ in. long, pale blue to purple, the calyx pubescent; pod slightly pubescent, $\frac{1}{4}$ in. long, $\frac{1}{8}$ in. wide, seeds 2, brown.

Introduced from Europe. Lake, Sandusky and Knox.

8. Vicia sativa L. Common Vetch. A three to five-branched climbing annual, 1–4 ft. high, with the stem 1/8 in. in diameter. Leaves 4–6 in. long, oval or obovate, 3/8–1/2 in. long, 1/8–1/4 in. wide, mucronate; tendrils branched; stipules broad. Peduncle short or wanting; flowers axillary 1–2, 1/2–3/4 in. long, purple, pod pubescent, 2–3 in. long, 3/16 in. wide, the 5–10 seeds brown to black.

Beneath the outer coat the seed of Vicia sativa is orange-yellow. It may readily be distinguished from Vicia villosa, which is lemon-yellow under the seed coat. Vicia sativa has been introduced from Europe, and is used as a forage or cover crop. Care must be observed in feeding this plant to pigs as cases of poisoning have been reported. It is also called Spring Vetch and Smooth Vetch.

9. Vicia angustifolia L. Narrow-leaf Vetch. A small climbing glabrous annual, 1–2 ft. long, the diameter of the stem 1/16 in. Leaves 2 in. long, leaflets, except the lower ones linear or linear oblong, 7/8–1 in. long, 1/16 in. wide; tendrils branched, the stipules half-sagittate, entire. Peduncle very short or wanting the flowers, 1–2 in the upper axils, purple; pods linear, glabrous, 1–2 in. long, 1/8–1/4 in. broad.

Vicia angustifolia has been introduced from Europe and is found escaped in Lake County.

3. Ervum L. Lentil.

Weakly erect herbaceous annuals with angled stems. Leaves pinnate, the leaves two to many; tendrils simple or compound, stipules semisagittate. Flowers small, racemose or solitary on axillary peduncles; calyx lobes elongated; style usually more or less hairy, flat; stamen tube diagonal at the summit; pod two-seeded.

1. Ervum lens L. Lentil. A glabrous or finely pubescent annual with a 4-angled stem 1–2 ft. high and 1/12–1/8 in. in diameter. Leaflets oblong, 3/4–1 in. long, 3/16–5/16 in. wide; tendrils branched, stipules semi-sagittate. Flowers 1/2–3/4 in. long, white to purple; pod 2-seeded, the seeds orbicular, gray or red.

The lens of optical instruments is named from its resemblance to this seed. The mess of pottage for which Esau sold his birthright to his brother Jacob is said to have been made of lentils. They are very commonly used for soup.

4. Lathyrus L.

Climbing or trailing vines with tendril-bearing leaves and often with a winged stem. Leaves ending in a simple or branched tendril; the leaflets 1–6 pairs; veining on the underside prominent; stipules generally smaller than the leaflets. Flowers racemose or solitary, generally showy, purple, yellow or white; stamen tube with a flat top; style without a groove, bearded along the inner side; pods dehiscent, the seeds brown to black.

Key to the Species.

1. Leaflets 1 pair. 2.
1. Leaflets 2-6 pairs. 3.
2. Stems wingless, flowers yellow. *Lathyrus pratensis.* (6).
2. Stems winged, flowers usually purple to white. 4.
3. Flowers purple. 5.
3. Flowers yellowish-white. *Lathyrus ochroleucus.* (5).
4. Stems broadly winged glabrous, perennial. *Lathyrus latifolius.* (7).
4. Stems narrowly winged, annual *Lathyrus odoratus.* (8).
5. Stipules broad, foliaceous, regularly halberd shaped, leaflets ovate. *Lathyrus maritimus.* (1).
5. Stipules narrow, half sagittate or wanting leaflets obovate. 6.
6. Inflorescence with 10-20 flowers. *Lathyrus venosus.* (2).
6. Inflorescence with 2-6 flowers. 7.
7. Leaflets linear or linear oblong, stems winged. *Lathyrus palustris.* (3).
7. Leaflets oblong or oval, stems wingless. *Lathyrus myrtifolius.* (4).

1. Lathyrus maritimus (L) Bigel. Beach Pea. A glabrous climbing or erect perennial with a grooved angled stem, 1–2 ft. high and 1/8 in. in diameter. Leaflets 2-6 pairs, oval, 1½ in. long, 1 in. wide, tendrils branched, stipules broad, foliaceous, and regularly halberd shaped. Peduncle shorter than the leaves; flowers 6–10, racemose, purple, 3/4–1 in. long; pod glabrous, 1½–3 in. long, ¼-½ in. wide, seeds 3–10, light brown.

Ashtabula, Lake, Cuyahoga and Erie. It is also called Sea-pea, Sea-side-pea and Everlasting-pea.

2. Lathyrus venosus Muhl. Veiny Pea. A trailing or climbing glabrous, or finely pubescent perennial, with a 4-angled stem, 2–3 ft. long and 1/8 in. in diameter. Leaflets 2–6 pairs, obovate, 1–2 in. long, ½–1 in. wide; tendrils compound, stipules narrow, half sagittate or wanting. Peduncles shorter than the leaves; flowers 10–20, ½–5/8 in. long, purple; pod linear, 1–3 in. long, 3/16–¼ in. wide; seeds 3–8, brown.

The Veiny Pea usually grows near rivers or lakes. Erie and Williams.

3. Lathyrus palustris L. Marsh Pea. A climbing, slightly pubescent or glabrous perennial with an angled, usually winged stem, 1–3 ft. long and 1/16 in. in diameter. Leaflets 2–6 pairs, linear or linear oblong, 1–2½ in. long, 3/8–5/8 in. wide; tendrils branched, stipules narrow, half sagittate or wanting. Flowers 2–6, ½ in. long, purple; pod linear, 2–2¼ in. long, 1/8–¼ in. wide, the seeds 3–6, brown.

The Marsh Pea is found in moist or wet soil. Lake, Cuyahoga, Summit, Erie, Madison and Greene. It is also called Wild Pea.

4. Lathyrus myrtifolius Muhl. Myrtle-leaf Marsh Pea. A slender climbing, glabrous, or slightly pubescent perennial, with a wingless, angled stem, 1–3 ft. long, and 1/16 in. in diameter. Leaflets 2–6 pairs, oblong or oval, 1–2 in. long, ¼–½ in. wide; tendrils branched; stipules ¼–3/8 in. long, narrow, half sagittate or wanting. Flowers 2–6, purple, ½–5/8 in. long; pod linear, 2 in. long, 3/16 in. wide, the seeds 3–8, brown.

This species is found in moist or wet localities. Lake, Stark, Erie, Lucas, Defiance and Auglaize.

5. **Lathyrus ochreoleucus** Hook. Cream-colored Pea. A climbing, or trailing glabrous perennial, the winged angled stem, 1–3½ ft. long, and ⅛ in. in diameter. Leaflets 6–10 acuminate or mucronate at the apex, rounded at the base, 1–3 in. long, ½–1 in. wide; tendrils simple or compound; stipules broad, foliaceous. Peduncles shorter than the leaves, the flowers 5–10, yellowish white, ½–¾ in. long; pod linear, glabrous, 1–2 in. long.

Lake, Cuyahoga, Lorain and Ottawa.

6. **Lathyrus pratensis** L. Meadow Pea. A weak trailing or climbing glabrous or slightly pubescent perennial with an angled stem 1–3 ft. long, and ¹⁄₁₆ in. in diameter. Leaflets 1 pair, lenear-oblong, acute, 1½–2 in. long; tendrils usually simple; stipules foliaceous, halberd-shaped. Flowers 4–12, ½–⅜ in. long, yellow, seeds small, brown.

The Meadow Pea is found in Lake County. It is also called Mouse Pea, Tom Thumb and Crow-peas.

7. **Lathyrus latifolius** L. Everlasting Pea. A climbing, glabrous perennial, with a broadly winged stem 3–10 ft. high and ⅛ in. in diameter. Leaflets 1 pair, 2–4 in. long, ½ in. wide, with prominent veining; tendrils branched; stipules lanceolate, 1 in. long. Peduncles stout, curved, longer than the leaves; the flowers purple to white, 1 in. long; pod 2–3 in. long, ¼ in. wide, the seeds 4–8, dark brown.

This plant is cultivated thruout Ohio for the beauty of the foliage and flowers, and is of especial value for ornamental gardening.

8. **Lathyrus odoratus** L. Sweet Pea. A rough hairy annual, with an angled, narrowly winged stem, 2–6 ft. long and ⅛ in. in diameter. Leaflets 1 pair, obovate acuminate, 2–4 in. long, ½–1 in. wide; tendrils many branched; stipules narrow. Flowers showy, ¾–1½ in. long, white to purple and often with many combinations of color; pod 1½–2 in. long, ¼ in. wide, the seeds 3–6 globular, brown.

The Sweet Pea is much cultivated on account of the beauty and odor of its flowers. They are raised in great numbers in greenhouses in winter, as well as in gardens in the summer. The cut flowers are used for general decoration and are universal favorites.

5. **Pisum** L. Pea.

Erect or climbing, glabrous, glaueous annuals with angled stems. Leaves ending with branching tendrils, the veining prominent; stipules larger or equalling the leaflets; flowers white to purple, the style usually more or less hairy, flattened, grooved on the under side, the stamen tube with a flat top; pod glabrous, the seeds globular or angular, smooth or wrinkled.

The Pea is cultivated to a large extent as a food for man and animals.

Key to the Species.

1. Flowers white, seeds globular. *Pisum sativum.* (1).
1. Flowers bluish to dull white with purple on the wings, seeds slightly angular, usually gray. *Pisum arvense.* (2).

1. Pisum sativum L. Common Pea. An erect or climbing glabrous annual with a hollow angular stem ½–6 ft. high and ⅛ in. in diameter. Leaflets 1–3 pairs, 1–2 in. long, ½–¾ in. wide, the stipules as large, or larger than the leaflets. Flowers ¼–½ in. long, white; pods 2–3 in. long, ¼–¾ in. wide, the seeds globular, green to yellow, smooth or wrinkled.

The Common Pea has been cultivated for food for many hundred years. The seed is used in the green or dry condition. By the use of a machine called the viner, the green peas are ready for the cans in a few hours after being cut, making it possible for the canned product to be in good condition. The ripe seed is used for split-pea soup.

2. Pisum arvense. L. Field Pea. A climbing or erect glabrous annual with an angular stem, 2–5 ft. high and ⅛ in. in diameter. Leaflets 1–3 pairs, 1–2 in. long, ½–¾ in. wide, the stipules as large or larger than the leaflets. Flowers ¼–½ in. long, blue to dull white with purple on the wings; pods 1½–2 in. long, ¼–¾ in. wide, the seed angular, usually gray.

The Field Pea is cultivated in Ohio for soiling, pasturage and dry feed. It thrives best in a cool, moist climate. For this reason, Canada has made the greatest advance in Field Pea culture. It is often called Canada Pea.

Phaseoleæ. Bean Tribe.

Dark-green herbs or vines usually pubescent, the stem round or roundish, erect or twining counter-clockwise. Leaves odd-pinnate, usually trifoliate, but leaflets sometimes 1–7. Flowers axillary, usually racemose, but sometimes capitate or solitary.

The cotyledons are usually pushed above ground during sprouting. The Phaseoleæ are cultivated for soiling, hay and seed. They supply an important part of the food of man.

Key to the Genera.

1. Leaves pinnate with 5–7 leaflets. *Glycine.* 2.
1. Leaves trifoliate or uniofoliate. 2.
2. Style bearded along the inner side. 3.
2. Style glabrous or pubescent only at the upper end or at the base. 4.
3. Flowers racemed, the keel of the corolla spirally coiled. *Phaseolus.* (5).
3. Flowers capitate, or if somewhat racemose, then the keel of the corolla only slightly incurved. 6.
4. Style bearded at the summit about the stigma. *Dolichos* (1).
4. Style glabrous at the upper end, sometimes pubescent at the lower part. 5.
5. Stem erect; annual; cultivated. *Soja.* (3).
5. Stem trailing; perennial; native. *Falcata.* (4).
6. Flowers capitate or in peduncle heads; corolla purple, keel of the corolla strongly incurved; native. *Strophostyles.* (6).
6. Flowers capitate or somewhat racemose, corolla yellow, white or purple. Keel of the corolla short, slightly incurved; cultivated. *Vigna.* (7).

1. Dolichos L.

Sparsely pubescent, erect, or twining annuals, the stem round, the leaves trifoliate, the stipules small. Flowers racemose, purple to white, the style bearded at the summit about the stigma; pod broad, the seeds black with a white raphe.

There is only one species generally cultivated in Ohio.

1. **Dolichos lablab** L. Hyacinth Bean. A pubescent twining annual with a reddish or green stem 2–8 ft. long and 1/8 in. in diameter. Leaflets 2–3 in. long, 1½–2 in. broad, minutely stipellate. Flowers showy, light purple, ½–1 in. long; pods broadly incurved, 1½–2½ in. long, 1 in. broad; the seeds black with a prominent white raphe.

The Hyacinth Bean is cultivated for the showy flowers. It is very hardy and will grow in almost any kind of soil. Escaped in Franklin County.

2. Glycine L.

Trailing or climbing pubescent or glabrous perennials. Leaflets 5–7. Roots tuberous or having prominent tubercles. Flowers axillary, racemose, capitate, showy, brownish purple to red.

1. **Glycine apios** L. Ground-nut. A slender trailing perennial, 2–10 ft. long and 1/16 in. or less in diameter. Leaflets 5–7, 1–4 in. long, ½–1½ in. wide. Flowers ¼–½ in. long, loosely racemose; pod linear, 3–5 in. long, ¼ in. wide, the seeds 5–9, reddish brown.

The roots are tuberous necklace-like, hence the name Groundnut. Stark, Auglaize, Clark, Harrison, Cuyahoga, Adams, Warren and Wayne. It is also called Wild Bean.

3. Soja Moench.

Erect pubescent annuals. Leaves trifoliate. Roots with many tubercles. Flowers greenish-white to purple, minute and inconspicuous; style glabrous at the upper end, sometimes pubescent at the lower part; pods brown, very pubescent.

1. **Soja soja** (L) Karst. Soy Bean. A pubescent annual 2–5 ft. high, the stem 1/8 in. in diameter. Leaflets 2½–3½ in. long, 1½–2½ in. wide. Flowers axillary, very minute, the parts early deciduous, greenish white to purple; pods 1½–2½ in. long, very pubescent; seeds white, green, yellow, brown, black or variegated, elliptical to spherical, 1/8–3/8 in. in diameter.

The Soy Bean has been introduced into the United States from China and is cultivated to a large extent for forage, hay, soiling and seed. The beans are now used both in the green and in the dry state, as food for man and animals.

4. **Falcata** Gmel.

Slender, glabrous or pubescent twining perennials. Leaves trifoliate. Flowers axillary racemose, white to purple, the style glabrous; pods linear oblong or obovoid, many to one seeded.

Key to the Species.

1. Glabrate or somewhat pubescent, the bracts small. *Falcata comosa.* (1).
1. Villous-brown pubescence, the bracts prominent. *Falcata pitcheri.* (2).

1. Falcata comosa (L) Ktz. Hog-Peanut. A slender, twining, glabrous or slightly pubescent perennial, the stem 1/8 ft. long, and less than 1/16 in. in diameter. Leaflets thin, acute at the apex, rounded at the base, 2½ in. long, 1½ in. wide, the bracts small. Flowers ½–¾ in. long, purple to white; pod 1 in. long, ¾ in. broad, the seeds 3–6, dark brown.

This plant is found in moist thickets. General. It is also called Pea Vine.

2. Falcata pitcheri (T. & G.) Ktz. Pitcher's Hog-peanut. Similar to the preceding, but generally stouter and villous-pubescent thruout, with reflexed brown hairs; leaflets larger and thicker; subterranean fruit less abundantly produced. In moist thickets; rather general in the State.

5. **Phaseolus** (Tourn.) L. Bean.

Twining or erect annuals, or perennials, leaves trifoliate. Flowers racemose axillary, white to purple, the style bearded along the inner side, the keel of the corolla spirally coiled; pod linear with a persistent style; the seed generally rounded at the ends.

Beans are almost universally cultivated for food of man. The dry and the green seed, as well as the green pods are used.

Key to the Species.

1. Flowers in racemes longer than the leaves. 2.
1. Flowers in racemes shorter than the leaves. 3.
2. Flowers small, 1-3 in. long, purple; native. *Phaseolus polystachyus.* (1).
2. Flowers large, ½ to 1 in. long, bright scarlet to white; cultivated. *Phaseolus coccineus.* (5).
3. Flowers greenish, white, pods, broad, seeds flat. *Phaseolus lunatus.* (4).
3. Flowers white to purple, pods linear, straight, seed usually oval. 4.
4. Stem erect. *Phaseolus nanus.* (3).
4. Stem twining, *Phaseolus vulgaris.* (2).

1. Phaseolus polystachyus (L) B. S. P. Wild Bean. A trailing or climbing perennial with the stem 4–15 ft. long and 1/16 in. in diameter. Leaflets broadly ovate, 2 in. long, 1½ in. wide, the stipules lanceolate. Flowers loosely racemose upon peduncles, longer than the leaves, the pedicels with minute bracts, each flower 1/6–1/3 in. in length, purple; pods curved, drooping, stalked flat 1½–2½ in. long; the seeds chocolate-brown.

2. Phaseolus vulgaris L. Common Pole Bean. A twining annual with the stem 4–10 ft. long, 1/16–1/8 in. in diameter. Leaflets 2–4 in. long, 1–3 in. wide. Flowers in racemes shorter than the leaves, 1/4–1/2 in. in length, white to purple; pods linear, 2–10 in. long, 3/4–1 1/4 in. wide, the seeds generally rounded at the ends, white, purple, brown, black and many combinations of color.

There are two general classes, green pod varieties and yellow or wax pod varieties. The common names for the different varieties are so confused that it is necessary to know the seed-house from which they come in order to know what they actually represent. Green snaps, green shelled and dry shelled are different forms used as food.

3. Phaseolus nanus L. Common Bush Bean. An erect, much branched annual, 1 1/2–3 ft. high, 1/16–1/8 in. in diameter. Leaflets 2–4 in. long, 1 1/2–3 in. wide. Flowers in racemes, shorter than the leaves, 1/4–1/2 in. in length, white to purple; pods linear, 2–8 in. long, 3/4–1 1/2 in. wide, green or yellow when young, the seeds oval tumid, white, purple, brown, black or variegated.

There are two general types, green pod and wax or yellow pod varieties. The extensive cultivation of the green pod varieties as a field crop for the dry seed probably accounts for the fact that many of these are of the tough shelled type. Beans are a popular article of diet, and owing to their high proteid content are used as a substitute for meat, but they should probably not be employed as a continuous, daily diet.

4. Phaseolus lunatus L. Lima Bean. An erect or twining annual, 1–10 ft. high, 1/16–1/12 in. in diameter. Leaflets usually acute at the apex, broad at the base, some linear, usually 2–4 in. long, 1–3 in. wide. Flowers 1/4–1/2 in. in diameter, greenish white pods, 3–7 in. long, 1–1 1/2 in. wide, somewhat pubescent, never edible at any stage of development; seeds generally flat, moon-shaped, the veining usually prominent, generally white, but some varieties with purple markings; 1/2–3/4 in. long, in the small bush varieties, to 1–2 in. in the large bush or climbing varieties.

The Lima Bean is widely cultivated for the seed as food in the green and the dry state.

5. Phaseolus coccineus L. Scarlet Runner Bean. A twining annual with a reddish-brown stem, 4–12 ft. long, 1/16–1/8 in. in diameter. Leaflets 2–6 in. long, 1–3 in. wide. Flowers in racemes, longer than the leaves, prominently scarlet, each flower 1/2–1 in. long; pods 2–5 in. long, 1/2–1 1/4 in. wide, the seeds 3–4, purple with black markings.

In sprouting, the cotyledons generally remain underground, altho in a few cases they are pushed above. It is usually cultivated on account of the beauty of the foliage and the flowers. The beans are said to be eaten by people of Europe and South America.

6. **Strophostyles** Ell.

Twining pubescent annuals, or perennials in pedunculate heads or sessile, purple; the keel of the corolla strongly incurved; style bearded along the inner side, the pods linear and straight.

1. Strophostyles helvola (L.) Britt. Trailing Wild Bean. A twining pubescent annual with the stem 2–8 ft. long and 1/16 in. in diameter. Leaflets lobed or regular, ovate at the base, acute at the apex, 1–3 in. long, 1–2 in. wide. Peduncles longer than the leaves, axillary; flowers 3–10, capitate, 1/3–1/2 in. long, purple; pod pubescent, the seed brown to black.

The range of territory from which this species is reported shows the distribution general over the state. Erie, Ottawa, Cuyahoga, Tuscarawas, Washington, Athens, Meigs, Hocking and Scioto.

7. **Vigna** Savi.

Twining or erect annuals. Leaves trifoliate. Flowers capitate or somewhat racemose, the keel of the corolla short, slightly incurved, yellow or white to purple; pods long, linear, the seeds small, light or dark, usually with a different coloring about the hilum.

Key to the Species.

1. Stem erect or slightly twining, 2–4 ft. long, pod 6–9 in. long. *Vigna sinensis.* (1).
2. Stem twining, 5–10 ft. long, pod 10–36 in. long. *Vigna sesquipedalis.* (2).

1. Vigna sinensis (L) Endl. China Bean. A twining or erect herbaceous annual, 2–4 ft. high, 1/16–1/8 in. in diameter. Leaflets 2–6 in. long, 1–3 in. wide, the stipules ovate or ovate lanceolate. Flowers 2/3–5/6 in. long, capitate or racemose, white or yellow to purple; pods 6–9 in. long, the seeds white to brown, having a contrasting ring of color around the hilum; seeds 4–20, separated in the pod by a coriaceous tissue.

The China Bean is being cultivated in Ohio for pasturage and as a soiling crop. It is also used for the food of man in the green and dry state. The China Bean has recently been called Cow Pea quite generally, especially in Agricultural Literature. But this name is confusing, since the plant is a typical species of the beans and is not at all like any of the peas.

2. Vigna sesquipedalis (L) Wight. Yard Bean. A climbing annual 5–10 ft. long, 1/16–1/8 in. in diameter. Leaflets 2–6 in. long, 1–3 in. wide. Flowers 2/3–1 in. long, yellow or white to purple; pod 10–36 in. long, 1/2 in. wide; seeds 10–20, light brown.

The Yard Bean is often cultivated for an ornament or curiosity, on account of its long pods. It is now generally used for food, when in the snap stage. It is also called Asparagus Bean.

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PREDICTING MINIMUM TEMPERATURES FOR FROST PROTECTION.

J. WARREN SMITH
(Professor of Meteorology, Columbus, Ohio.)

The question of protecting fruit and truck crops from frost damage by building fires of oil, coal, or wood, is receiving considerable attention in Ohio and some 40 to 50 of the most progressive fruit and truck men are now practicing orchard heating.

The United States Weather Bureau has encouraged these efforts by establishing special frost-fruit stations for the purpose of studying local temperature conditions and for giving information as to the probable temperatures that may be expected on nights when frost damage is likely.

It is known that fruit buds will stand lower temperatures at some periods of their growth than at others and that the minimum temperature will vary greatly under different topographic conditions. The ability to determine approximately the lowest temperature for any night when fruit buds or truck crops are in a critical condition will determine whether plans must be laid for starting the fires.

The officials of the Weather Bureau by studying the approaching weather conditions from the daily weather maps and by a knowledge of the average daily range in temperature, the dew point temperature, and the varying temperature under different elevations makes very close temperature forecasts and sends this information to a large number of places in the State where heating is practiced.

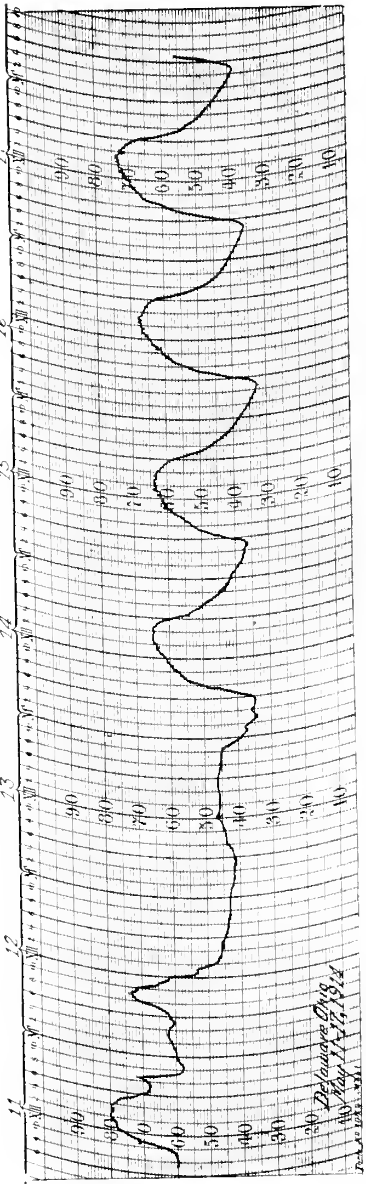


Fig. 1. Record made by a self recording thermometer at Delaware, Ohio, May 11 to 17, 1914.

It seems important, however, that some plan be devised whereby a fruit man not in touch with the Weather Bureau and its maps and forecasts can closely estimate the probable lowest temperature at critical periods.

In investigating this point in connection with our special fruit service in Ohio, we have found that the prediction of the minimum temperature from the time of the average afternoon median temperature gives very close results.

Figure 1 is a copy of the temperature record made by a self recording thermometer at Delaware, Ohio, from May 11 to May 17, 1914. This shows a rapid fall in temperature beginning at about 10 a. m. of the 12th. This was due to a shift of the wind to northwesterly and the small change that occurred in the temperature from the afternoon of the 12th to the early morning of the 14th was because of continued northerly winds and rainy weather.

Beginning on the 14th, however, and continuing through the balance of this week and most of the following week, there was a period of clear and comparatively still weather when an area of high barometer pressure was centered over this district. Under these conditions the temperature rises high during the daytime under strong sunshine, and then falls quite low at night under free radiation. It is under conditions of this kind that frosts may be expected in the spring and fall. It will be noticed that the rise in temperature is rapid in the early forenoon and that the thermograph curve has a decidedly convex shape.

The highest temperature will be reached at about 3 o'clock in the afternoon. The temperature will fall slowly for two or three hours, then there will be a rapid fall in the evening and a slower fall until the lowest point just before sunrise. The afternoon curve has a decided concave shape. There is a marked similarity in the curves during these days when frosts threaten.

This being true the question was raised whether the half way point in the temperature fall from the maximum of one day to the minimum of the next morning might not occur at about the same time each evening.

A study of available records showed that in May the half way temperature occurred at Delaware on an average at 7:36 p. m. and that the variations on either side of this time was less than 20 minutes in either 1913 or 1914.

For example the highest temperature at Delaware on May 14, 1914, as shown by the thermograph record in Figure 1, was 65. The temperature at 7:36 p. m., the average time of the median, was 51. Subtracting this from the maximum leaves 14. If we take 14 from 51 then we shall have 37 as the predicted minimum temperature during the coming night, by this method. The lowest temperature that actually occurred was 36 or only 1 lower than estimated.

On the 15th the predicted temperature would be 34, while the thermometer reached 33. On the 16th and 17th the exact minimum would have been predicted.

Rules to follow. The average time of this median hour will vary under different weather conditions, at different seasons of the year, and in different localities. Outside of the cities, in central Ohio, under conditions of clear skies and comparatively still air, it will be close to the following.

April, 7:15 p. m.; May and June, 7:30 p. m.; September, 6:30 p. m.; October and November, 6 p. m. In July it is about 7:30 p. m., and in August, 7 p. m.

If a strong wind is blowing in the afternoon or if the afternoon is cloudy or partly cloudy, and the wind goes down and it clears off in the night the time of the median temperature will be from 30 to 45 minutes later than the average given.

If it should cloud up during the night after a clear afternoon and evening the minimum temperature will not be quite so low as is indicated by the median.

In cloudy and stormy weather, or when strong southerly winds prevail, or if the wind is high from the northwest the time of the median varies so much that no attempt should be made to make predictions from it.

This is especially true when after a period of warm weather the wind shifts to northwesterly and the temperature begins to fall rapidly. This indicates the approach of a cool area and the only way to estimate the probable minimum temperature is from the daily weather maps.

But after the windy front of this cool wave has passed by and the air is clear and still and the days are warm and the nights cool and frosts threaten then the plan can be used.

Reliable maximum and minimum thermometers should be obtained and exposed in a lattice work shelter where the air circulates freely and the sun will not strike the instruments.

The difference in temperature between that at the average half-way or median hour should be subtracted from the highest during the day and the difference subtracted from the reading at the half way hour. The remainder will show the approximate lowest temperature during the coming night.

Records that are at hand indicate that the average time of median will be slightly later in the valleys than at higher elevations, but each man interested should be able to determine his own median hour by careful records of the temperature.

The Weather Bureau office at Columbus will continue its study during the coming year at a larger number of stations than were in operation last year.

A PRELIMINARY SURVEY OF PLANT DISTRIBUTION IN OHIO.*

John H. Schaffner

The following data are presented as a preliminary basis for field work in determining the natural plant areas of Ohio. It is hoped that the botanists of the State will begin active study of local conditions with a view to determine natural or transition boundaries as well as cataloging local associations. The distribution lists are based on herbarium material and more than 15 years of sporadic botanizing in the state. Of course, distribution at present indicates to a considerable extent merely the distribution of enthusiastic botanists and their favorite collecting grounds. Nevertheless, enough has been done to indicate in a rough way the general character of our plant geography.

The kind of data most important in indicating characteristic areas are as follows:—

1. Meteorological data.
2. Geology, including the nature of the surface rock and soil.
3. Physiography and topography.
4. The actual distribution of characteristic species of plants and to some extent of animals.

In Ohio, the following important maps may be studied in this connection:—

Meteorology.

By Otto E. Jennings in Ohio Naturalist 3: 339-345, 403-409, 1903. Maps I-XII.

By J. Warren Smith in Bull. Ohio Agr. Exp. Station No. 235, 1912. Figs. 3-14.

Geology.

By J. A. Bownocker, A Geological Map of Ohio. 1909.

Topography.

The maps of the topographic survey, not yet completed. Various geological reports.

The eastern half of Ohio is a part of the Alleghany Plateau. The western half belongs to the great interior plain. In Ohio, the Alleghany Plateau consists of a northern glaciated region and a southern non-glaciated region. The latter apparently again divides into an eastern and western plant area.

The interior plain consists of a southern glaciated calcarious region up to the Ohio River—Lake Erie water shed, and north of this of the very flat Great Black Swamp region and its margin. The northwestern corner apparently has a characteristic flora differing in many respects from the Black swamp area, and is probably to be regarded as a distinct region mostly beyond our borders.

*Contribution from the Botanical Laboratory of the Ohio State University. No. 86.

The region of Sandusky Bay and the islands is peculiar in many respects, being a meeting place of many species. The Sandusky area is apparently a biological island containing numerous species heretofore not discovered in any other part of the state. The Sugar Grove area also contains a number of unusual isolated species but is not so sharply defined as the Sandusky Bay area.

Important Geographic Boundaries in Ohio.

There is a general transition belt between the eastern and western portions of the state, situated between the eastern limit of the Ohio Shale on the one hand and the glacial boundary and the limit of the higher hill country on the other. See Map I. The lake shore may also be considered as a more or less distinct plant area, but such details are not considered in this paper.

According to Merriam, the northeastern part of Ohio belongs to the Transition Zone and all the rest of the state to the Upper Austral Zone.

In map I are indicated some of the more important physiographic lines in Ohio as follows:

a-a, Western boundary of the Alleghany Plateau, following closely the eastern limit of the Ohio Shale.

b-b, The terminal moraine or glacial boundary.

c-c, Lake Erie Ohio River divide.

d-d, North-west beach of glacial Lake Erie; the country beyond this is deeply covered with drift underlain with shale.

e, Edge of the higher hill country.

According to all the data available and the lists of plants given below, Ohio apparently falls into four general regions or areas and for a preliminary survey seven natural plant regions may be recognized. These areas will at present not receive final, distinctive phytogeographic names but be indicated simply by their physiographic character or their geographic position as follows: (See Map II.)

I. Glaciated Alleghany Plateau, belonging to the "Transition Zone."

II. Non-glaciated Alleghany Plateau, eastern division, including most of the Muskingum river basin, and the counties to the east.

III. Non-glaciated Alleghany Plateau, western division, containing the highland between the Muskingum and Scioto.

IV. The Miami Area, mainly a glaciated calareous region.

V. The Great Black Swamp Area and contiguous country.

VI. The Williams County Area.

VII. Sandusky Bay and Lake Erie Islands Area.

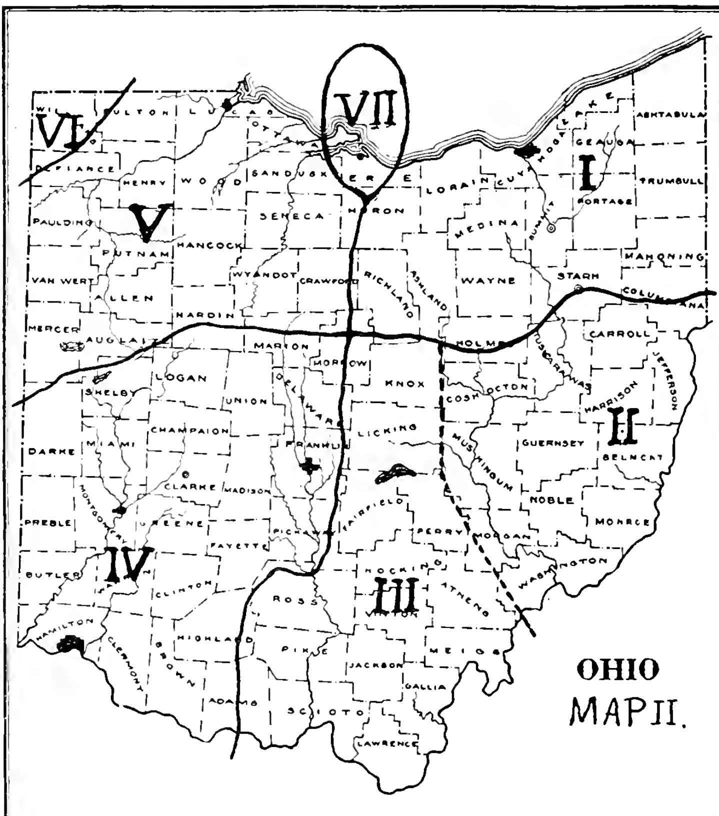
The seven areas may be briefly delimited and characterized as follows:—

I. The Glaciated Alleghany Plateau has its southern boundary in the terminal moraine and its western boundary at or a little beyond the limits of the Appalachian highland which approaches the eastern line of the Ohio Shale. As stated this area is recognized as a part of the Transition Zone of Merriam. Interesting plants found in this part of the state are:

Pinus strobus
Calla palustris
Xyris flexuosa
Lysias orbiculata
Pyrola secunda
Andromeda polifolia

Others are named in the list given below of "Northeastern and northern plants having a north-eastern distribution in Ohio."

II. The Eastern Division of the non-glaciated Alleghany Plateau extends eastward from an undetermined transition line west of the Muskingum valley. This area apparently lacks the white pine and tamarack present to the north and also the pitch



Provisional Phytogeographic Areas of Ohio.

pine and sorrel tree of the rougher highland to the west. The scrub pine is also apparently absent except on the western edge. Isolated localities have Juniperus virginiana and Tsuga canadensis.

III. The Western Division of the non-glaciated Alleghany Plateau included in this area has its western boundary following closely the eastern limit of the Ohio Shale in southern Ohio and the terminal glacial moraine. It is a rugged hilly upland cut by

numerous deep ravines. Pine barrens, mostly consisting of Pinus virginiana are frequent. The distribution of the more important Ohio species, which are mostly if not entirely confined to this area and are rather generally distributed in a considerable part of it are as follows:

Distribution of Nine Species in the Western Part of the Non-glaciated Alleghany Plateau.

Rather Generally Distributed in a Considerable Part of the Area.

Pinus rigida
Pinus virginiana. Extends somewhat beyond.
Aristida dichotoma.
Stylosanthes biflora.
Betula nigra.
Oxydendrum arboreum.
Dasystoma laevigata.
Salvia lyrata.
Solidago erect.

Other Plants Apparently Confined to the Area and of Rarer Distribution.

Selanginella rupestris.
Manfreda virginica.
Magnolia tripetala.
Viola hirsutula.
Viola pedata.
Silene rotundifolia.
Sullivantia sullivantii.
Quercus marilandica.
Quercus triloba.
Azalea lutea.
Rhododendron maximum.
Epigaea repens. Its southern extension in Ohio.
Gaultheria procumbens. Its southern extension in the State.
Chionanthus virginica.
Anisostichus capreolata.
Lobelia puberula.
Coreopsis major.
Chrysopsis mariana.
Ionactis linariifolius.
Eupatorium rotundifolium.
Eupatorium aromaticum.

IV. The Miami Area is a glaciated area mainly calcareous. It is drained by the big and little Miami rivers and small tributaries of the Scioto and Ohio. The Ohio-Erie divide may be taken as its northern boundary. Juniperus virginiana is its only conifer with the exception of a few isolated records of hemlock, except in the eastern part where Thuja occidentalis occurs in isolated groups, from Franklin county southward to Adams county. The arbor-vitae is not known to be native of any other part of the state. Juniperus virginiana, which is the only conifer of general distribution in the central deciduous forest region and the prairie of the United States, is rather common especially toward the southwest. A number of southwestern plants occurring in this area are listed below.

V. The Great Black Swamp Area is a great level tract, including most of northwestern Ohio except the extreme corner. It is drained mainly by the Maumee and Sandusky Rivers. The typical black swamp is characterized by the entire absence of conifers except Larix laricina which occurs on its margins. Originally there were a number of edaphic prairies in this region like the "Big Spring Prairie" in Hancock, Seneca and Wyandot counties.

VI. The Williams County Area may be bounded in Ohio by the ancient Lake Erie beach, extending in a southwesterly direction. It includes also a small part of Fulton and Defiance counties. The surface is generally rolling with marshes and water-basins, often without natural drainage, presenting the usual features of moraine districts. There are a number of tamarack bogs with the accompanying vegetation. This characteristic area extends westward into Indiana and northward into Michigan and is probably the southern part of the Ann Arbor flora quite distinct from the contiguous Maumee flora.

VII. The Sandusky Bay and Lake Erie Islands Area is a distinctive region where eastern, western, and northern plants meet. In many respects it is an island where isolated species of

plants and animals are common. There are numerous peculiar plant associations on sand hills and prairies and on the lime-stone islands to the north and west of Sandusky Bay. Of interest are fields of Opuntia near Sandusky, the Meibomias of Margaretta Ridge, and the prairie plants south of Lakeside. Stipa spartea is aboundant on Cedar Point and such plants as Bearberry (Uva-ursi) and Prunus pumila are represented by a few individuals. The flora of the entire region is probably strongly influenced by the climatic conditions of the Bay. A list of distinctive species is given below.

Northern Plants With Northern Distribution in Ohio.

Botrychium simplex.
Botrychium neglectum.
Matteuccia struthiopteris.
Equisetum variegatum.
Equisetum sylvaticum.
Lycopodium obscurum.
Larix laricina.
Juniperus communis.
Juniperus sibirica.
Taxus canadensis.
Sagittaria cuneata.
Potamogeton amplifolius.
Potamogeton friesii.
Potamogeton robbinsii.
Vallisneria spiralis.
Sparganium simplex.
Cyperus schweinitzii.
Eleocharis ovata.
Scirpus torreyi.
Carex sartwellii.
Carex siccata.
Carex setacea.
Carex diandra.
Carex disperma.
Carex trisperma.
Carex straminea.
Carex communis.
Carex pedunculata.
Carex richardsonii.
Carex aurea.
Carex gracillima.
Carex arctata.
Carex virescens.
Carex buxbaumii.
Carex lacustris.
Carex atherodes.
Carex oederi.
Carex monile.
Carex retrorsa.
Carex lupuliformis.
Panicularia grandis.
Poa debilis.
Koeleria cristata.
Triplasis purpurea.
Beckmannia erucaeformis.
Sporobolus cryptandrus.
Calamagrostis canadensis.
Ammophila arenaria.
Lilium philadelphicum.
Vagnera trifolia.
Juncus balticus.
Juncus alpinus.
Juncus articulatus
Juncus scirpoides.
Pogonia ophioglossoides.
Coptis trifolia.
Anemone cylindrica.
Actaea rubra.
Sarracenia purpurea.
Capnoides aureum.
Arabis brachycarpa.
Cakile edentula.
Robertiella robertiana.
Chamaesyce polygonifolia.
Hibiscus moscheutos.
Hypericum kalmianum.
Hypericum ellipticum.
Hypericum boreale.
Hypericum majus.
Hypericum canadense.
Tracaulon arifolium.
Persicaria careyi.
Potentilla paradoxa
Rubus neglectus.
Sorbus scopulina.
Prunus pumila.
Lathyrus maritimus.
Lathyrus ochroleucus.
Lepargyraea canadensis.
Nemopanthus mucronata.
Comptonia peregrina.
Populus balsamifera.
Salix lucida.
Salix adenophylla.
Salix candida.
Salix petiolaris.
Salix bebbiana.
Salix humilis.

Salix pedicellaris.
Ribes lacustre.
Chamaenerion angustifolium.
Epilobium adenocaulon.
Oenothera oakesiana.
Chamaedaphne calyculata.
Uva-ursi uva-ursi.
Vaccinium canadense.
Vaccinium atrococcum.
Oxycoccus macrocarpus.
Gentiana flavida.
Apocynum sibiricum.
Asclepias pulchra.
Dasystoma pedicularia.
Otophylla auriculata.
Melampyrum lineare.
Utricularia intermedia.
Myosotis laxa.
Lithospermum carolinense.
Aralia nudicaulis.
Panax trifolium.
Galium boreale.
Viburnum pubescens
Campanula rotundifolia.
Megalodonta beckii.
Gnaphalium decurrens.
Anaphalis margaritacea.
Antennaria neodioica.
Solidago hispida.
Solidago arguta.
Aster ptarmicoides.
Hieracium canadense

Northeastern and Northern Plants Having a Northeastern Distribution in Ohio.

Botrychium lanceolatum.
Phegopteris dryopteris.
Drytoperis clintoniana.
Drytoperis dilatata.
Isoetes braunii.
Isoetes foveolata.
Lycopodium inundatum.
Lycopodium clavatum.
Selaginella apus.
Pinus strobus.
Scheuchzeria palustris.
Potamogeton epihydrus.
Potamogeton praelongus.
Potamogeton obtusifolius.
Calla palustris.
Eriphorum viridicarinatum.
Carex deweyana.
Carex alata.
Carex flexuosa.
Carex flava.
Panicularia canadensis.
Panicularia torreyana.
Danthonia compressa.
Deschampsia flexuosa.
Milium effusum.
Panicum xanthophysum.
Lilium umbellatum.
Trillium undulatum.
Clintonia borealis.
Xyris flexuosa.
Limnorchis hyperborea.
Lysias orbiculata.
Lysias hookeriana.
Ibidium strictum
Ibidium plantagineum.
Trollius laxus.
Aconitum noveboracense.
Cardamine pratensis.
Lechea stricta.
Viola rotundifolia.
Blitum capitatum.
Comarum palustre.
Dalibarda repens.
Alnus incana.
Grossularia oxyacanthoides.
Hottonia inflata.
Pyrola secunda.
Hypopitys lanuginosa.
Ledum groenlandicum.
Azalea viscosa.
Andromeda polifolia.
Chiogenes hispidula.
Menyanthes trifoliata.
Aralia hispida.
Conioselium chinense.
Hydrocotyle americana.
Cynoxylon canadense.
Viburnum dentatum.
Viburnum cassinoides.
Viburnum alnifolium.
Lonicera canadensis.
Lonicera oblongifolia.
Linnaea americana.
Solidago squarrosa.
Aster phlogifolius.
Doellingeria infirma.

The Plants Having a General Distribution East and South of the State Which Should Have a Southeastern Distribution in Ohio.

Andropogon virginicus.
Acalypha ostryaefolia.
Ilex opaca.
Kalmia latifolia.
Scutellaria integrifolia.
Cunila origanoides.
Salvia lyrata.
Chrysopsis mariana.
Solidago erecta.

Eastern Plants Having Mostly an Eastern Distribution in Ohio.

Asplenium pinnatifidum.
Asplenium montanum.
Lycopodium complanatum.
Tsuga canadensis.
Clintonia umbellulata.
Cardamine rotundifolia.
Dentaria diphylla.
Linum virginianum.
Viola hastata.
Silene caroliniana.
Rubus odoratus.
Spiraea tomentosa.
Chrysosplenium americanum.
Castanea dentata.
Betula lenta.
Betula lutea.
Kneiffia pumila.
Chimaphila maculata.
Epigaea repens.
Polycodium stamineum.
Galium pilosum.
Vernonia noveboracensis.
Hieracium paniculatum.
Hieracium venosum.

Plants Mainly South of the State and Which Should Have a Rather General Southern Distribution in Ohio.

Asplenium resiliens.
Woodsia obtusa.
Pinus rigida.
Pinus virginiana.
Aristida dichotoma.
Panicum bicknellii.
Pancium implicatum.
Panicum boscii.
Manfreda virginica.
Corallorrhiza wisteriana.
Magnolia tripetala.
Delphinium tricorne.
Viorna viorna.
Stylophorum diphyllum.
Phyllanthus carolinensis.
Hypericum virgatum.
Viola pedata.
Passiflora lutea.
Sagina decumbens.
Alsine pubera.
Silene rotundifolia.
Amaranthus spinosus.
Porteranthus stipulatus.
Chamaecrista nictitans.
Psoralea onobrychis.
Stylosanthes biflora.
Rhamnus lanceolota.
Rhamnus caroliniana.
Ampelopsis cordata.
Aesculus octandra.
Liquidambar styraciflua.
Quercus stellata.
Quercus marilandica.
Quercus triloba.
Betula nigra.
Hydrangea arborescens.
Phoradendron flavescens.
Oxydendrum arboreum.
Diospyros virginiana.
Ipomoea lacunosa.
Chionanthus virginica.
Gentiana villosa.
Gonolobus laevis.
Vincetoxicum obliquum.
Anisostichus capreolata.
Trichostema dichotomum.
Scutellaria serrata.
Stachys cordata.
Aralia spinosa.
Houstonia purpurea.
Viburnum scabrellum.
Lobelia puberula.
Lobelia leptostachys.
Coreopsis major.
Antennaria solitaria.
Elephantopus carolinianus.
Mesadenia reniformis.
Lactuca villosa.

Plants of the Southwestern and Western U. S. Which Should Have a Southwestern Ohio Distribution. Such a distribution is at present indicated by specimens.

Polypodium polypodioides.
Hordium nodosum.
Tradescantia pilosa.
Ranunculus micranthus.
Arenaria patula.
Trifolium stoloniferum.
Lavauxia triloba.
Cuscuta indecora.
Synthyris bullii.
Orobanche ludoviciana.
Phacelia bipinnatifida.
Phaethusa helianthoides.
Boebera papposa.
Grindelia squarrosa.
Eupatorium serotinum.

Plants From the West Which Should Show a General Western Distribution.

Zanthoxylum americanum.
Gymnocladus dioica.
Valeriana pauciflora.
Mesadenia tuberosa.
Lactuca floridana.

Plants of Distinctly Northwestern Distribution and Which Apparently Have Advanced Into Ohio From the West.

Stipa spartea.
Chamaesyce serpens.
Viola pedatifida.
Salix glaucophylla.

Plants Known Only From the Sandusky Bay Region, Many of Which May Have a Wider Distribution in the State.

Botrychium simplex.
Juniperus sibirica.
Sagittaria cuneata.
Potamogeton hillii.
Potamogeton friesii.
Potamogeton interruptus.
Sparganium simplex.
Wolffia punctata.
Eleocharis ovata.
Rynchospora cymosa.
Mariscus mariscoides.
Scleria triglomerata.
Scleria pauciflora.
Carex sartwellii.
Carex siccata.
Carex setacea.
Carex disperma.
Carex richardsonii.
Carex aurea.
Carex meadii.
Carex crawei.
Carex haydeni.
Carex atherodes.
Carex oederi.
Melica nitens.
Panicularia pallida.
Poa debilis.
Koeleria cristata.
Ammophila arenaria.
Stipa spartea.
Panicum agrostoides.
Panicum philadelphicum.
Lilium superbum.
Juncus balticus.
Juncus scirpoides.
Capnoides aureum.
Arabis brachycarpa.
Linum medium.
Linum sulcatum.
Chamaesyce serpens.
Hypericum gymnanthum.
Hypericum majus.
Hypericum canadense.
Persicaria careyi.
Polygonum tenue.
Potentilla paradoxa.
Prunus pumila.
Meibomia illinoensis.
Lespedeza nuttallii.
Lespedeza stuvei.
Ammannia coccinea.
Rhexia virginica.
Salix adenophylla.
Opuntia humifusa (also in Scioto County.)
Ribes lacustre.
Oenothera oakesiana.
Myriophyllum verticillatum.
Uva-ursi uva-ursi.
Gentiana puberula.
Gratiola sphaerocarpa.
Otophylla auriculata.
Houstonia angustifolia.
Galium claytoni.
Campanula rotundifolia.
Bidens discoidea.
Tetraneuris herbacea.
Solidago arguta.
Aster dumosus.
Aster ptarmicoides.
Vernonia fasciculata.
Vernonia missurica.
Artemisia caudata.
Senecio pauperculus.
Nabalus asper.

Interesting Plants in the Licking, Fairfield, Hocking County Area.

Selaginella rupestris.
Wolffiella floridiana.
Poa autumnalis.
Stenanthium robustum.
Ibidium beckii.
Viola hirsutula.
Meibomia marylandica.
Epilobium strictum.
Hypopitys americana.
Azalea lutea.
Rhododendron maximum.
Phlox stolonifera.
Phacelia dubia.
Utricularia minor.
Eupatorium rotundifolium.
Eupatorium aromaticum.
Lactuca sagittifolia.

THE ROSES OF OHIO.

Rose Gormley.

Rosaceæ—Rose Family.

Herbs, shrubs, or trees with bisporangiate, rarely diecious, actinomorphic, perigynous flowers, and alternate, simple or compound, usually stipulate leaves; perianth usually pentamerous, the calyx often bracteolate; stamens usually numerous, anthers with four microsporangia; carpels one to many, distinct or united with each other and the hypanthium; ovulary unilocular or in cases of united carpels 2–10–locular; style terminal or lateral; ovules one to several, anatropous; fruit usually follicles, achenes, drupes or pomes; endosperm usually none, rarely copious.

Subfamily, Rosatæ.

Carpels several or numerous or occasionally only one and then the fruit a dry, one-seeded achene; hypanthium free from the carpels, usually membranous, but sometimes becoming dry or fleshy in the fruit, fruit follicles, achenes, aggregates of drupelets, or with fleshy receptacle.

SYNOPSIS.

I. Carpels not enclosed in the hypanthium; calyx not enclosing the carpels.
- a. Carpels numerous, ripening into 1–2-seeded achenes or drupelets.
  - 1. Style persistent; fruit an achene.
    - 1. Geum. (1).
  - 2. Style deciduous; fruit an achene.
    - 2. Dasiphora. (2).
    - 3. Potentilla. (3).
    - 4. Argentina. (4).
    - 5. Comarum. (5).
    - 6. Drymocallis. (6)
    - 7. Waldsteinia. (7).
    - 8. Fragaria. (8).
  - 3. Style persistent; fruit a drupelet.
    - 9. Rubus. (9).
- b. Carpels usually not more than 10, ripening into 1–4-seeded follicles.
  - 1. Flowers bisporangiate.
    - 10. Porteranthus. (10).
    - 11. Schizonotus. (11).
    - 12. Filipendula. (12).
    - 13. Opulaster. (13).
    - 14. Spiraea. (14).
  - 2. Flowers diecious.
    - 15. Aruncus. (15).

II. Carpels at length enclosed in the connivant, zygomorphic calyx segments; styles deciduous; with normal or cleistogamous flowers.
- 16. Dalibarda. (16).

III. Carpels enclosed in the persistent hypanthium; achenes numerous to one.

a. Achenes numerous, enclosed in a fleshy hypanthium.
17. Rosa. (17).

b. Achenes 1–2, enclosed in the dry hypanthium.
18. Agrimonia. (18).
19. Sanguisorba. (19).
20. Poterium. 20).

Genus Key.

1. Carpels not enclosed in the hypanthium. 2.
1. Carpels enclosed in the hypanthium. 17.
2. Carpels numerous, ripening into 1–2-seeded achenes or drupelets. 3.
2. Carpels usually not more than 10. 11.
3. Plants woody, usually prickly, or, if not, with shreddy bark. 4.
3. Plants herbaceous, rarely slightly woody at the base. 5.
4. Flowers white or rose; shrubs usually prickly; fruit an aggregate of drupelets. *Rubus*. (9).
4. Flowers yellow; not prickly or bristly; bark shreddy, achenes pubescent. *Dasiphora*. (2).
5. Leaves trifoliate; flowers corymbose on a scape. 6.
5. Leaves pinnate or lobed or, if trifoliate, then the flowers solitary in the axils or cymose at the end of leafy branches. 7.
6. Flowers yellow; achenes on dry receptacles. *Waldsteinia*. (7).
6. Flowers white; achenes on fleshy edible receptacles. *Fragaria*.
7. Style terminal or nearly so; achenes glabrous or pubescent. 8.
7. Style lateral or nearly basal; achene glabrous. 9.
8. Seed erect; style persistent, jointed near the tip, becoming hooked. Geum. (1).
8. Seed pendulous; style deciduous, articulated with the ovulary, not becoming hooked. *Potentilla*. (3).
9. Flowers red or purple. *Comarum*. (5).
9. Flowers yellow or white. 10.
10. Flowers white; style nearly basal. *Drymocallis*. (6).
10. Flowers yellow; style lateral; plant silvery pubescent. *Argentina*. (4).
11. Leaves entire or only slightly lobed. 15.
11. Leaves compound or deeply palmately lobed. 12.
12. Shrubs with odd pinnate leaves, stipules small. *Schizonotus*. (11).
12. Erect perennial herbs. 13.
13. Leaves 2–3 times pinnate; stipules minute or wanting. *Aruncus*. (15).
13. Leaves palmately lobed, 3-foliate or simply pinnate; stipules large. 14.
14. Leaves 3-parted or 3-foliate; flowers in loose terminal panicles; follicles dehiscent along both sides. *Porteranthus*. (10).
14. Leaves pinnately 3–9-lobed or foliate; flowers in dense cymose panicles; follicle-like fruit indehiscent. *Filipendula*. (12).
15. Low herbs with orbicular, cordate leaves; hypanthium zygomorphic enclosing the carpels; with normal and cleistogamous flowers. *Dalibarda*. (16).
15. Shrubs; leaves ovate orbicular, ovate or lanceolate; hypanthium enclosing the carpels. 16.
16. Leaves somewhat 3-lobed; follicles dehiscent along both sutures; carpels united below. *Opulaster*. (13).
16. Leaves entire; follicles dehiscent along one suture, carpels distinct. *Spiraea*. (14).
17. Shrubs; stems usually prickly; carpels enclosed in the fleshy hypanthium. *Rosa*. (17).
17. Herbs; stems not prickly; carpels enclosed in a dry hypanthium. 18.

18. Leaves pinnate with smaller leaf segments between the larger ones; calyx with hooked prickles; flowers with petals in narrow racemes. *Agrimonia* (18).
18. Leaves pinnate without the smaller leaf segments; calyx without prickles; flowers without petals in heads or spikes. 19.
19. Leaves $\frac{3}{4}$–$2\frac{1}{2}$ in. long; stamens 4; inflorescence a spike. *Sanguisorba*.(19)
19. Leaves $\frac{1}{4}$–$\frac{1}{2}$ in. long; stamens numerous; inflorescence a head. *Poterium*. (20).

1. **Geum.** Avens.

Perennial herbs with pinnate or pinnatified leaves with stipules; flowers solitary or cymose—corymbose; perianth segments 5 each; stamens numerous; achenes numerous on a dry receptacle, the persistent styles being straight or jointed, naked or plumose; seed erect, testa membranous.

1. Flowers purple; calyx lobes erect or spreading; style plumose below. *G. rivale*. (1).
1. Flowers white or yellow; calyx lobes strongly reflexed in fruit; style not plumose. 2.
2. Calyx without bracts; flowers less than $\frac{1}{4}$ in. broad, yellow; head of fruit long stalked. *G. vernum*. (6).
2. Calyx bracteolate; flowers $\frac{1}{4}$–$\frac{3}{4}$ in. broad. 3.
3. Petals white. 4.
3. Petals yellow or cream yellow. 5.
4. Plants glabrate or softly pubescent; receptacle bristly. *G. canadense*. (2).
4. Plants rough-pubescent; receptacle glabrous or downy. *G. virginianum*.(4)
5. Stems bristly-hairy, $1\frac{1}{2}$–3 ft. tall; petals cream-yellow, small, rarely exceeding the sepals. *G. flavum*. (3).
5. Stems pubescent, 2–5 ft. tall; petals yellow, large, much exceeding the sepals. *G. strictum*. (5).

1. **Geum rivale** L. Purple Avens. Erect herbs, $1\frac{1}{2}$–$2\frac{1}{2}$ ft. high; basal leaves pinnate, the side leaflets being much smaller than the terminal leaflets, irregularly lobed and dentate; stem leaves simple or 3-parted; flowers purple, styles becoming plumose in the fruit. Geauga, Champaign.

2. **Geum canadense** Jacq. White Avens. Erect, softly pubescent or glabrate herbs, branched at the top, $1\frac{3}{4}$–3 ft. high; leaves 3-parted, ovate or obovate, velvety pubescent or glabrate beneath; flowers, white. General.

3. **Geum flavum** (Port.) Bickn. Cream-colored Avens. Stems erect, $1\frac{1}{2}$-3 ft. tall, bristly-hairy below; stipules large, foliaceous; leaves usually pinnate, those above sometimes entire; flowers cream-yellow; head of fruit sessile. No specimens.

4. **Geum virginianum** L. Rough Avens. Stems with bristly hairs $1\frac{1}{4}$–2 ft. high; petals creamy-white, rather inconspicuous, being exceeded by the sepals; receptacle glabrous or downy. Lorain, Wyandot, Highland, Wayne, Fulton, Madison, Mercer, Licking, Richland, Knox, Clinton, Huron, Galion, Defiance, Harrison, Fayette, Morrow, Tuscarawas, Williams.

5. **Geum strictum** Ait. Yellow Avens. Stems hairy, $1\frac{1}{2}$–$2\frac{3}{4}$ ft. high. Stem leaves pinnate, much incised, leaflets 3–5, rhombic-ovate; stipules large, foliaceous; flowers yellow; petals longer than the sepals, orbicular in shape. Knox, Ashtabula, Summit, Wayne, Lake, Stark, Lorain, Cuyahoga, Fairfield, Geauga, Preble.

6. **Geum vernum** (Raf.) T. & G. Spring Avens. Stem erect, glabrous, or with a few scattered hairs; basal leaves orbicular or cordate, 3–5 lobed, sometimes pinnate; stem leaves narrowly pinnate or pinnatified; flowers yellow, head of fruit long stalked. Hancock, Montgomery, Clark, Warren, Lucas, Erie, Lorain, Delaware, Greene, Hamilton, Pickaway, Crawford, Hardin, Clermont, Preble, Huron, Licking, Franklin, Pike, Auglaize, Washington, Madison, Morrow.

2. Dasiphora.

Stems shrubby, erect, with dry sheathing stipules and pinnate leaves; flowers solitary or in small cymes; petals and sepals 5; stamens about 25 in 5 festoons on the thickened margin of the disk; achenes numerous, densely covered with hairs.

1. **Dasiphora fruticosa** (L.) Rydb. Shrubby Cinquefoil. Shrubs $\frac{1}{2}$–$2\frac{1}{2}$ ft. high, with shaggy bark; leaflets 5–7, oblong, entire, with long, silky hairs; flowers yellow, $\frac{3}{8}$–$\frac{1}{2}$ in. broad. Erie, Champaign, Wyandot, Clarke, Montgomery, Summit, Portage, Stark, Logan.

3. Potentilla. Cinquefoil, Five-finger.

Herbs or shrubs with digitate or pinnate, compound leaves; flowers cymose or solitary, yellow in ours; calyx 5-lobed (rarely 4-lobed), 5-bracteolate (rarely 4-bracteolate), persistent; petals 5, rarely 4); carpels inserted on a dry, usually pubescent receptacle.

1. Flowers cymose; erect or ascending herbs. 2.
1. Flowers solitary, axillary; prostrate or creeping herbs. 5.
2. Leaves pinnately 3–11-foliate. *P. paradoxa.* (1).
2. Leaves palmately 3–7-foliate. 3.
3. Leaflets 3. *P. monspeliensis.* (4).
3. Leaflets 5–7. 4.
4. Leaflets crenate, green beneath; lower stipules leaf-like; petals dark yellow. *P. recta.* (3).
4. Leaflets laciniate or incised, white-pubescent beneath; stipules not leaflike. *P. argentea.* (2).
5. Flowers 4-parted, upper leaves 3-parted. *P. reptans.* (7).
5. Flowers 5-parted; leaves usually all 5-foliate. 6.
6. Stems long, ascending at first, 5-14 in. high, later decumbent; pubescence of petioles, stems and peduncles spreading. *P. canadensis.* (5).
6. Plants low, not more than 4 in. high with very slender runners; pubescence of petioles, stems and peduncles oppressed. *P. pumila.* (6).

1. **Potentilla paradoxa** Nutt. Bushy Cinquefoil. Plants stout, bushy; stems decumbent or erect; leaves pinnately 5-11-foliate; leaflets obovate or oval, deeply incised; flowers borne in leafy cymes. Erie County.

2. **Potentilla argentea** L. Silvery Cinquefoil. Stems 3–10 in. high, ascending, rather woody at the base; leaflets usually 5, incised, oblanceolate, or obcordate, green and glabrous above, silvery white beneath, calyx white, wooly. Licking, Erie, Cuyahoga.

3. **Potentilla recta** L. Upright Cinquefoil. Stems erect, 1–1½ ft. high, villous; flowers yellow, about ½ in. broad, leaves 5–7-parted; leaflets oblanceolate or oblong-lanceolate, sparingly pubescent. Hocking, Franklin, Erie, Lake.

4. **Potentilla monspeliensis** L. Rough Cinquefoil. Stems erect, 1-2½ ft. high, often much branched above; leaflets 1½–2 in. long, obovate, obtuse, pubescent; flowers about $\frac{3}{8}$ in. broad, yellow; sepals exceeding the petals in length. General in distribution.

5. **Potentilla canadensis** L. Common Five-finger. Plants decumbent, often rooting at the tip; stems 5–14 in. high; leaves usually 5-parted; leaflets oblong, serrate, silky hairy beneath; flowers yellow, $\frac{1}{2}$–$\frac{5}{8}$ in. broad. General.

6. **Potentilla pumila** Poir. Dwarf Five-finger. Plants very low, with slender prostrate runners; flowering stems upright at first, later producing prostrate runners; leaves 5-parted, silky pubescent; leaflets obovate, lighter beneath, sharply dentate; flowers $\frac{3}{8}$–$\frac{3}{4}$ in. broad, yellow. Lawrence, Monroe, Vinton, Lake.

7. **Potentilla reptans** L. European Five-finger. Prostrate herbs with very slender, almost filiform stems; leaves five-parted; leaflets, cuneate-oblanceolate, dentate almost to the base; flowers yellow, petals obcordate, one-half longer than the sepals. Lake County.

4. **Argentina.** Silverweed.

Low perennial herbs with pinnate leaves and producing long runners; flowers yellow, solitary, appearing from the axils of the leaves; bracts, sepals and petals 5 each; stamens numerous; style lateral; mature achenes with a thick, corky pericarp.

1. **Argentina anserina** (L.) Rydb. Silverweed. Leaves 2–9 in. long; leaflets $\frac{3}{8}$–1 in. long, oblong or oblanceolate, obtuse, under surface white, silky pubescent; flowers yellow, ½–1 in. broad. Lorain, Lucas, Ottawa, Hamilton, Erie, Cuyahoga.

5. **Comarum.** Marshlocks.

Herbs with alternate, pinnate leaves and large purple, solitary or cymose flowers, either terminal or axillary; calyx 5-lobed with 5 bracts; petals 5, shorter than the calyx lobes, stamens numerous, inserted on a pubescent receptacle which is spongy in fruit.

1. **Comarum palustre** L. Purple Marshlocks. Plants 1–1½ ft. high; leaves pinnate, 5–7-foliate; leaflets oblong or oblaneeolate, sharply serrate above the middle, narrowing at the base ¾–3 in. long; stipules large, usually membranous; flowers large, ½–¾ in. broad, purple. Lorain, Summit, Ashland, Portage, Licking, Stark, Ashtabula.

6. Drymocallis.

Erect herbs with more or less glandular or viscid stems and pinnate leaves; calyx 5-practeolate; sepals and petals 5; stamens 20–30 in number in 5 festoons on a thick glandular disk; style nearly basal.

1. **Drymocallis agrimonioides** (Pursh) Rydb. Tall Cinquefoil. Erect, stout herb, 1–3 ft. high; leaflets oval or ovate, sharply incised-serrate, terminal one cuneate, the others rounded at the base; flowers white, cymose. Cuyahoga, Erie, Lake.

7. Waldsteinia.

Perennial herbs resembling strawberries, with 3-parted leaves and yellow corymbose flowers; sepals, petals and bractlets 5; stamens many, inserted on the throat of the hypanthium; carpels usually 2–6 on a short, villous receptacle, style deciduous, terminal.

1. **Waldsteinia fragarioides** (Mx.) Tratt. Dry Strawberry. Low herb with creeping rootstalk; leaflets obovate, broadly cuneate, crenate, sometimes incised, ½–1¼ in. long; flowers yellow, ⅜–⅝ in. broad. Cuyahoga, Clarke, Franklin, Ashtabula, Greene, Medina, Portage.

8. Fragaria. Strawberry.

Perennial herbs with runners, three-parted leaves, and membranous sheathing stipules; flowers white, corymbose or racemose, pedicels often recurved; calyx 5-bracteolate; petals 5; stamens many; carpels indefinite; leaflets obovate, cuneate, serrate; fruit consisting of a fleshy receptacle in which are inserted the achenes, seed ascending, amphitropous.

1. Achenes in pits of the pulpy receptacle; inflorescence umbelliform or a flattish topped cyme, with subequal primary branches; sepals lanceolate, appressed about the fruit; hairs spreading or sub-appressed on scape and petiole. *F. virginiana.* (3).
1. Achenes superficial; inflorescence irregular, the primary branches of the cyme being distinctly unequal; sepals loosely spreading or reflexed, shorter than the early exposed fruit; hairs appressed on the petiole, spreading on the scape. 2.
2. Plants slender; fruit conical or subcylindric-ovoid, red. *F. americana.* (1).
2. Plants stoutish; fruit ovoid-conic or subglobose, white in our form. *F. vesca.* (2).

1. **Fragaria americana** (Porter) Britt. American Wood Strawberry. Leaves thin, light green, pubescence usually closely appressed and silky or sparse; inflorescence irregular and somewhat raceme-like primary branches of the cyme distinctly unequal; fruit ovoid to conic. Butler, Greene, Cuyahoga, Ottawa, Auglaize, Crawford, Summit.

2. **Fragaria vesca** L. European Wood Strawberry. The white-fruited variety. Low herbs, with the pubescence of the petioles wide-spreading, that of the pedicels closely appressed; inflorescence, a cyme; fruit ovoid or hemispherical, white. Hocking, Belmont.

3. **Fragaria virginiana** Duch. Virginia Strawberry. Taller than the above species, rather stout, villous pubescent; leaves 5–12 in. tall; leaflets thick, ovate, light gray-green below, 1–3½ in. long; inflorescence a flat-topped cyme; achenes in pits in the receptacle. General in distribution.

9. **Rubus.** Blackberry, Raspberry, Dewberry.

Perennial shrubs with erect or trailing stems, usually prickly; leaves alternate, simple or 3–7-parted, with stipules adnate to the petiole; flowers terminal or axillary, solitary, racemose or panicled; calyx 5-parted, without bracts; petals 5; stamens many; carpels many, inserted on a convex or elongated receptacle, ripening into drupelets, usually edible; styles nearly terminal.

1. Flowers purplish, rose or light pink; stems bristly. 2.
1. Flowers white, or if not, then not bristly. 3.
2. Leaves simple, 3–5-lobed or angled, not white beneath; stems not prickly; petals purple-rose. *R. odoratus.* (10).
2. Leaves usually 3-parted; white-downy beneath; petals pale pink; fruit enclosed in a bur. *R. phoenicolasius.* (9).
3. Leaves white-downy beneath; stems more or less glaucous; fruit easily separated from the dry receptacle. 4.
3. Leaves sometimes lighter green below, not white-downy; stems not glaucous; fruit persistent on the receptacle or not easily separated from it. 6.
4. Stems very glaucous all over, with rather stout recurved prickles, not bristly; fruit purple-black. *R. occidentalis.* (5).
4. Stems slightly glaucous; bristly; fruit red. 5.
5. Stems bristly, not prickly; fruit light red. *R. strigosus.* (7).
5. Stems both bristly and prickly; fruit a dark red. *R. neglectus.* (6).
6. Canes erect or arched ascending; inflorescence elongated, many-flowered. 7.
6. Canes trailing or with a tendency to be prostrate toward the end; inflorescence loose, few-flowered, racemose, or flowers solitary. 8.
7. Inflorescence with few (4–6) or several unifoliate leaves. *R. frondosus.* (1).
7. Inflorescence not leafy. *R. alleghaniensis.* (2).
8. Stems herbaceous, usually anarmed, but sometimes with occasional prickles; fruit red purple. *R. triflorus.* (8).
8. Stems shrubby; with prickles or bristles; fruit black or nearly black when ripe. 9.
9. Stems with few prickles; leaves dull above; fruit black. *R. procumbens.* (3).
9. Stems slender, densely set with weak bristles; leaves shining; fruit reddish-black. *R. hispidus.* (4).

1. **Rubus frondosus** Bigel. Leafy-flowered Blackberry. Erect, about 3 feet high, villous when young; leaves 3-parted, lighter beneath; prickles slender and straight; infloresecence dense, usually with unifoliate leaves; flower about 1 in. broad. Coshocton, Gallia, Hancock, Lake, Columbiana.

2. **Rubus alleghaniensis** Port. High Blackberry. Plants shrubby, branched, glandular-pubescent, 3-10 ft. high, leaves 3–5-parted, infloresecence terminal, racemose-paniculate; flowers 1–1¼ in. broad. General.

3. **Rubus procumbens** Muhl. Common Dewberry. Trailing shrubs with few or no prickles; branches erect, 3–9 in. tall; leaves 3–7-foliate; leaflets oval, rounded or narrowed at the base, rather finely and sharply dentate, sometimes serrate. General.

4. **Rubus hispidus** L. Hispid Dewberry. Stems slender, densely set with weak bristles; branches slender, 3–9 in. long; leaves 3-foliate; leaflets ovate or obovate, sharply serrate; flowers corymbose, small, about ¼ in. broad; fruit red, small, about ¼ in. long. Ashtabula, Lucas, Cuyahoga, Portage, Geauga, Logan, Summit, Lake.

5. **Rubus occidentalis** L. Black Raspberry. Stems recurved, very glaucous, sometimes 12 ft. long, armed with stout recurved prickles, which are usually in pairs; leaves 3–5-parted; leaflets ovate, acumenate, serrate, infloresecence corymbose; fruit black, hemispheric. General.

6. **Rubus neglectus** Peck. Purple Raspberry. Stems 1–3 ft. long, glaucous, sparingly bristly and prickly; leaflets ovate, sharply serrate, very white beneath; infloresecence corymbose, terminal; flowers, white; fruit dark-red or purple. Williams, Stark, Defiance, Ashtabula.

7. **Rubus strigosus** Mx. Wild Red Raspberry. Branched biennial shrub, 3–6 ft. high with many weak glandular bristles, leaves 3–5-foliate, white, velvety-pubescent beneath leaflets, ovate to ovate oblong, acuminate, rounded at the base; inflorescence racemose; flowers $\frac{1}{4}$–$\frac{3}{8}$ in. broad; fruit red. Summit, Erie, Clarke.

8. **Rubus triflorus** Richards. Dwarf Raspberry. Stems trailing or ascending; leaves 3–5-foliate; leaflets ovate-lanceolate, acute, rather coarsely serrate; flowers 1–3 on a peduncle, pink or white; fruit red-purple, rather large, acid. Sandusky, Stark, Lorain, Brown, Wyandot, Crawford, Vinton, Wood, Champaign, Lake, Lucas, Fairfield.

9. **Rubus phoenicolasius** Max. Wineberry. Stems densely covered with reddish-brown prickles and gland-tipped hairs; leaves 3–5-parted, white pubescent beneath; leaflets broadly ovate; fruit red, enclosed in the bur-like calyx. Lake County.

10. **Rubus odoratus** L. Rose-flowered Raspberry. Shrubby covered with glandular hairs; leaves simple, 3–5-lobed; peduncles many-flowered; flowers purple-red; fruit red, not edible. Ashtabula, Summit, Jefferson, Belmont, Cuyahoga, Monroe, Muskingum, Lake.

10. Porteranthus.

Perennial herbs; leaves nearly sessile, stipulate, 3-foliate; flowers white or pink, in loose terminal panicles; calyx cylindric, 5-toothed; petals 5, lance-linear; stamens 10–20; carpels 5, opposite the calyx lobes; follicles 2–4-seeded.

1. Stipules narrow, usually entire. *P. trifoliatus.* (1).
1. Stipules broad, foliaceous, incised. *P. stipulatus.* (2).

1. **Porteranthus trifoliatus** (L.) Britt. Indian-physic. Erect, branching herbs, 2–4 ft. high, usually glabrous though sometimes pubescent; leaves with narrow entire stipules; leaflets ovate or lanceolate, acuminate, serrate, 2–3 in. long; flowers few, in panicles, pink or white; follicles pubescent. No specimens.

2. **Porteranthus stipulatus** (Muhl.) Britt. American Ipecac. Less pubescent than the above species; stipules broad, foliaceous, sharply serrate; leaves usually narrower than in the above; follicles usually glabrous. Ross, Gallia, Pike, Clinton, Muskingum Adams, Guernsey, Belmont.

11. Schizonotus.

Shrubs with pinnately divided leaves; flowers in terminal panicles; calyx campanulate, 5-parted; petals 5, white; stamens numerous, carpels 5, united at the base.

1. **Schizonotus sorbifolius** (L.) Lindl. Mountain-ash Spiraea. An erect shrub, pubescent when young; leaves 3–12 in. long, 13-21-parted; leaflets lanceolate acuminate, doubly serrate; panicle large, white. Harrison, Lake.

12. Filipendula.

Tall perennial herbs with pinnately divided leaves; flowers small, borne in large cymose panicles; sepals and petals 5; stamens numerons on a flat or slightly concave receptacle; carpels 5–15; fruit resembling a follicle, indehiscent.

1. **Filipendula rubra** (Hill.) Rob. Queen-of-the-prairie. Stem tall, often more than 8 feet, branched, leaves pinnately 3–7 foliate; leaflets lighter green beneath, irregularly serrate; terminal leaflet palmately 7–9-parted; flower ¾ in. broad. Champaign, Madison, Erie, Cuyahoga, Holmes.

13. Opulaster. Ninebark.

Branched shrubs, with simple lobed leaves; calyx campanulate, 5-parted; petals 5, in the throat of calyx; stamens 20–40; carpels 1–5; pods 1–5, dehiscent longitudinally.

1. **Opulaster opulifolius** (L.) Ktz. Ninebark. Shrub 3–10 ft. high, the bark peeling off in strips; leaves ovate-orbicular, 3-lobed, coarsely dentate; flowers white or purplish, in terminal corymbs; follicles dehiscent along two sides. General.

14. Spiraea.

Shrubs with bisporangiate, pink or white flowers, borne in panicles, racemes, cymes or corymbs; sepals and petals 4 or 5; stamens 20–60, distinct; carpels usually 5, alternate with the sepals; follicles 5; seed pendulous, testa dull.

1. Leaves finely serrate, not tomentose; flowers borne in tomentulose panicles. *S. alba.* (1).
1. Leaves unequally and coarsely serrate, tomentose; flowers borne in narrow, dense, brownish tomentose panicles. *S. tomentosa.* (2).

1. **Spiraea alba** DuR. Narrow-leaf Spiraea. Tall shrub, sometimes 6 ft.; leaves narrowly lanceolate, sharply and finely serrate; flowers white, borne in narrow panicles; fruit glabrous. General.

2. **Spiraea tomentosa** L. Steeple-bush (Spiraea). Erect, shrubby, usually tomentose; leaves ovate, 1–2 in. long, unequally serrate, glabrous and dark green above, wooly pubescent below; flowers pink or purple, in dense terminal panicles. Stark, Hocking, Cuyahoga, Summit, Portage, Lucas, Gallia, Wayne, Fairfield, Jackson.

15 Aruncus.

Perennial herbs, leaves usually 2-pinnate, flowers diecious, almost sessile in panicled spikes; calyx usually 5-lobed; petals white, as many as the lobes of the calyx; carpels usually 3; style persistent; follicles reflexed, splitting on the ventral suture.

1. **Aruncus aruncus** (L.) Karst. Aruncus. Herb, erect, glabrous, 3–6 ft. high; leaflets ovate, lanceolate, acuminate, rounded or cordate at the base; sharply and doubly serrate. Monroe, Columbiana, Tuscarawas, Gallia, Licking, Fairfield, Lawrence, Hocking, Jackson, Belmont, Vinton, Scioto.

16. Dalibarda.

Low perennial herb with creeping stems and simple, orbicular, cordate, crenate leaves, flowers 1 or 2, borne on a scape-like petiole, of two kinds, a few upright sterile ones, the others fertile, cleistogamous and without petals.

1. **Dalibarda repens** L. Dalibarda. Low downy herbs; sepals of the sterile flowers spreading, those of the cleistogamous flowers converging and enclosing the fruit. Ashtabula County.

17. **Rosa.** Rose.

Erect or climbing shrubs, usually with prickly stems; leaves odd-pinnate; stipules adnate to the leaves; flowers showy, bisporangiate; hypanthium urn-shaped, becoming fleshy in the fruit; ovularies hairy, ripening into bony achenes.

1. Leaflets mostly 3; styles united in a slender exserted column; prickles very stout, almost as broad at the base as long. *R. setigera.* (6).
1. Leaflets 5–9; styles distinct; prickles recurved or straight and slender, not nearly so broad as long. 2.
2. Leaflets small, ½–¾ in. long, orbicular to ovate, pale beneath and very glandular. *R. rubiginosa.* (4).
2. Leaflets larger, ¾–2 in. long, ovate to narrowly oblong, not glandular. 4.
3. Leaflets ovate, rounded at the base, doubly and glandular serrate; flowers deep pink to crimson, 2–3 in. broad. *R. gallica.* (5).
3. Leaflets oblong, acute at the base, not prominently glandular, serrate; flowers pink, 1–2 in. broad. 4.
4. Stems smooth or with very few weak prickles; flowers on smooth peduncles; sepals erect on the fruit, not deciduous. *R. blanda.* (1).
4. Stems with straight prickles, usually in pairs; sepals spreading, deciduous. 5.
5. Prickles stout and recurved; leaflets finely serrate; stipules convolute; hypanthium bristly. *R. carolina.* (2).
5. Prickles slender and straight; leaflets coarsely dentate; stipules flat. *R. virginiana.* (3).

1. **Rosa blanda** Ait. Smooth Rose. Stems 1–5 ft. high, usually without prickles; leaflets 5–7, ovate or oblong-lanceolate, thin; flowers pink, about 2 in. broad. Lorain, Mercer, Clermont, Erie, Clinton, Williams, Lake.

2. **Rosa carolina** L. Swamp Rose. Stems 1–8½ ft. tall with stout, straight or curved prickles; leaflets 5–9, usually 7, dark green, narrowly oblong, finely serrate, usually pubescent beneath; flowers pink, 1½ in. broad, corymbose or rarely solitary. Franklin, Holmes, Trumbull, Hocking, Stark, Logan. Defiance, Gallia, Crawford, Shelby, Monroe, Ottawa, Huron, Lake, Ashtabula, Auglaize, Cuyahoga, Tuscarawas, Fairfield, Geauga, Clarke, Medina, Licking, Miami, Knox, Fulton, Williams, Lorain, Summit, Brown.

3. **Rosa virginiana** Mill. Virginia Rose. Stems ½–6 ft. high, densely set with long, straight prickles; leaflets 5–7, small, obovate, sharply serrate; flowers pink. General.

4. **Rosa rubiginosa** L. Sweetbrier (Rose). Stems 3–6½ ft. high, with stout, recurved prickles; leaflets 5–7, ovate or oval, doubly serrate, very glandular beneath; fruit oval, glandular. Ottawa, Lorain, Highland, Ashtabula, Madison, Hancock, Brown, Preble, Jefferson, Morrow, Monroe, Morgan, Licking, Miami, Greene, Wayne, Ross, Montgomery, Williams, Warren, Coshocton, Noble, Guernsey, Knox.

5. **Rosa gallica** L. French Rose. Stem with straight slender prickles; leaflets usually 5, elliptic, cordate at the base, doubly glandular-serrate; flowers double, red and large. Lake County.

6. **Rosa setigera** Mx. Prairie Rose. Stems climbing, with stout, rather straight prickles; leaflets 3–5, usually 3, ovate, sharply serrate; petals rose-colored, sometimes white. Clarke, Fayette, Jefferson, Greene, Williams, Hocking, Erie, Perry, Clermont, Muskingum, Montgomery, Lucas, Madison, Tuscarawas, Harrison, Butler, Lorain, Highland, Auglaize, Defiance, Gallia, Logan, Shelby, Miami.

18. **Agrimonia.** Agrimony.

Erect perennial herbs, leaves with large stipules, odd pinnate, with smaller leaf segments between the larger ones; flowers yellow, borne in narrow racemes; sepals 5; petals 5; stamens 5–15; carpels 2; fruit with 1–2 dry achenes.

1. Leaflets 11–17, lanceolate to narrowly lancelinear, bristles radiate. *A. parviflora.* (1).
1. Leaflets 5–11, ovate to obovate or elliptic-oblong. 2.
2. Fruit with few erect, ascending or conivant bristles. 3.
2. Fruit with many radiating bristles. *A. gryposepala.* (2).
3. Under surface of leaves usually glabrous or with few scattered hairs, minutely glandular. *A. rostellata.* (3).
3. Under surface of leaves closely and softly pubescent. 4.
4. Leaves glandular-dotted beneath; leaflets 5–11; fruit with slender ascending bristles nearly in a single row; roots tuberous. *A. mollis.* (4).
4. Leaves not glandular-dotted beneath; leaflets 7–9; fruit with short conivant or inflexed bristles; roots not tuberous. *A. striata.* (5).

1. **Agrimonia parviflora** Sol. Small-flowered Agrimony. Erect herb, 1–4 ft. high; stems brownish, hirsute; flowers small, in long, slender racemes; leaflets 11–17, lanceolate to narrowly lance-linear, acuminate, sharply serrate; flowers $\frac{1}{8}$–$\frac{1}{4}$ in. broad; fruit top-shaped, ridges, with reflexed radiate bristles. Auglaize, Belmont, Cuyahoga, Putnam, Montgomery, Huron, Franklin, Scioto, Trumbull, Carroll, Ottawa, Logan, Wood, Union, Wyandot.

2. **Agrimonia gryposepala** Wallr. Hairy Agrimony. Plants 1–6 ft. tall with few bristly hairs, minutely glandular; leaves usually 7-foliate, leaflets large, $1\frac{1}{2}$–5 in. long, elliptic or oblong, coarsely serrate; flowers less than $\frac{1}{4}$ in. broad, yellow; fruit top-shaped, deeply ridged. Stark, Logan, Belmont, Madison, Summit, Fayette, Erie, Ashtabula, Wayne, Harrison, Highland, Defiance.

3. **Agrimonia rostellata** Wallr. Woodland Agrimony. Stems about 1–5 ft. tall, minutely glandular; leaflets mostly 5, ovate-oblong, crenate or dentate; flowers $\frac{1}{4}$–$\frac{3}{8}$ in. broad; bristles erect

or ascending, short and weak. Madison, Cuyahoga, Lake, Montgomery, Miami, Wayne.

4. **Agrimonia striata** Mx. Striate Agrimony. Plants 2–6 ft. tall; leaflets thick, dull green, softly pubescent below, glabrate above; flowers $\frac{1}{4}$–$\frac{1}{2}$ in. broad; fruit with short, often purplish bristles which are inflexed or connivant. Huron, Clinton.

5. **Agrimonia mollis** (T. & G.) Britt. Soft Agrimony. Stem pubescent or villous; leaves thick, dark green above, pubescent below; leaflets obovate cuneate; flowers $\frac{1}{4}$–$\frac{3}{8}$ in. broad; fruit top-shaped, deeply furrowed. Morgan, Highland, Williams, Erie, Huron, Tuscarawas, Meigs, Clermont, Licking, Scioto.

19. Sanguisorba.

Erect perennial herbs with odd-pinnate leaves; flowers borne in a dense terminal spike; calyx 4-parted, stamens 4, inserted on the hypanthium; carpels enclosed in the hypanthium.

1. **Sanguisorba canadensis** L. American Burnet. Stems slender, glabrous, 1–6 ft. high, with leaflike stipules; leaflets $\frac{3}{4}$–$2\frac{1}{2}$ in. long, oblong, cordate, coarsely serrate; flowers greenish-yellow, borne in a dense spike. Lake, Champaign, Cuyahoga, Clarke, Franklin, Miami, Stark.

20. Poterium.

Erect, slender, perennial herbs with odd-pinnate, stipulate leaves; flowers borne in dense heads, bisporangiate or monosporangiate; calyx 4-angled; petals 4; stamens numerous; carpels 2; achene enclosed in the hypanthium.

1. **Poterium sanguisorba** L. Garden Burnet. Herbs 10–20 in. high; leaves pinnate; leaflets 7–19, ovate, deeply incised, $\frac{1}{4}$–$\frac{1}{2}$ in. long; flowers greenish, borne in a head. Lake County.

NEW AND RARE PLANTS ADDED TO THE OHIO LIST IN 1914.

John H. Schaffner.

The following records of new and rare plants have been made for the year and are to be added to the new "Catalog of Ohio Vascular Plants." Additions are inserted with decimal fractions; records of new distribution with the appropriate numbers from the list as published.

170. Scirpus planifolius Muhl. Flat-leaf Club-rush. In woods; Strasburg, Tuscarawas County. V. Sterki.

597. Tipularia unifolia (Muhl.) B. S. P. Crane-fly Orchis. Reported from Ashtabula County. R. J. Sim.

701.1. Lepidium perfoliatum L Perfoliate Peppergrass. Naturalized at Kent, Portage County. From Europe. L. S. Hopkins.

1393. Ledum groenlandicum Oedr. Labrador Tea. From "May Swamp" in Portage County. L. S. Hopkins.

1760. Diodia teres Walt. Rough Buttonwood. East Cleveland, Cuyahoga County. Edo Claassen.

Three species were added while the catalog was going thru the press and therefore have fractional numbers. These are the following:

563.1. Dioscorea bulbifera L. Air Potato (Yam).
1053.1. Sorbus aucuparia L. European Mountain-ash.
1273.1. Quercus triloba Mx. Spanish Oak.

As is usual with linotype printing, a number of errors appear in the catalog. Mistakes can readily be corrected by reference to Britton & Brown's "Illustrated Flora," Second Edition. The first line numbered 1043 should be erased. The following species were lost out bodily in the final forms:

1045. Rosa setigera Mx. Prairie Rose. General, but no specimens from the Northeastern Counties.

1520. Scrophularia marylandica L. Maryland Figwort. General.

2024. Cirsium odoratum (Muhl.) Britt. Fragrant Thistle. Ashtabula County.

THE OHIO ACADEMY OF SCIENCE.

The twenty-fourth annual meeting of the Ohio Academy of Science was held at Ohio State University, Columbus, on November 26, 27 and 28, 1914, under the presidency of Dr. T. C. Mendenhall, of Ravenna.

The address of the President was delivered Friday evening, on the subject "Some Pioneers of Science in Ohio," and on Saturday morning the Academy listened to a very timely lecture upon "Foot and Mouth Disease" by Dean D. S. White of the College of Veterinary Medicine of Ohio State University.

The trustees of the research fund announced a further gift of $250.00 from Mr. Emerson McMillin, of New York, for the encouragement of the research work of the Academy.

In accordance with the report of a committee appointed a year ago, the Academy voted to deposit the library of the Academy with the library of Ohio State University—an arrangement which may be terminated by either party on suitable notice.

The matter of the celebration of the annual meeting of 1915 as a Quarter Centennial Anniversary was referred to the Executive Committee.

Twenty-three new members were elected, making the total membership of the Academy two hundred and fifty four.

The officers of the Academy for the year 1914-15 are as follows.

President—Professor J. Warren Smith, Ohio State University and Ohio Section U. S. Weather Bureau.

Vice-Presidents—(Zoology) Professor F. C. Waite, Western Reserve University; (Botany) Professor F. O. Grover, Oberlin College; (Geology) Professor C. G. Shatzer, Wittenberg College; (Physics) Professor J. A. Culler, Miami University.

Secretary—Professor Edward L. Rice, Ohio Wesleyan University.

Treasurer—Professor J. S. Hine, Ohio State University.

Librarian—Professor W. C. Mills, Ohio State University.

Executive Committee, together with the President, Secretary, and Treasurer, members ex-officio,—Professor C. D. Coons, Denison University; Professor T. M. Hills, Ohio State University.

Board of Trustees of the Research Fund—Professor W. R. Lazenby, Ohio State University; Professor M. M. Metcalf, Oberlin College; Professor N. M. Fenneman, University of Cincinnati.

Publication Committee—Professor J. H. Schaffner, Ohio State University; Professor C. H. Lake, Hamilton; Professor L. B. Walton, Kenyon College.

The complete scientific program follows:

PRESIDENTIAL ADDRESS.

Some Pioneers of Science in Ohio..........Dr. T. C. Mendenhall

LECTURE.

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Delaware, Ohio, December 5, 1914.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, April 20, 1914.

This meeting was held in conjunction with the Natural History Society and was called to order by the President of the Natural History Society, Mr. Meekstroth. The reading of the minutes was omitted.

Prof. Dachnowski had the first paper of the evening on "Certain Problems of Plant Growth." In his experiments he found that the absorption of glycocoll is not connected with the transpirational water loss but with the efficiency of the nutritive metabolism and with the amount of water retained within the plant and involved in metabolism. The retention of water and not the transpirational water loss is the physiological function, correlated with, and indispensable to growth in general.

Mr. Reese had a paper on Introduced Insects in which he discussed the various introduced pests that bother American horticulturists and vegetable gardners.

The meeting then adjourned.

Blanche McAvoy, Secy.

Date of Publication, January 14, 1915.

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AND

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EFFICACY OF LIGHTNING RODS.

J. WARREN SMITH.

FIRE LOSSES.

It is stated on good authority that in the United States fire costs over $500 a minute. The National Fire Prevention Association of New York states that fire losses and the cost of fire protection amounts to $450,000,000 in the United States each year. This is $850 a minute.

Fire Losses Due to Lightning.—The Wisconsin Fire Marshal says that lightning in this country destroys more property than matches, sparks, and kerosene together, and more than any other cause, except defective flues.

Figures gathered from the reports of the State Fire Marshals in Iowa, Indiana, and Ohio, for 1913, indicate that the number of fires due to lightning was one-sixth of the number from all causes and the loss by lightning one-eleventh of the total fire loss.

In the summer of 1914, the writer gathered statistics from 121 Mutual Fire Insurance Companies operating in 15 different States, largely in the central part of the country. These statistics show that in 1913 the total number of buildings burned from any cause was 1,174. During the same year 809 buildings were struck by lightning and damaged and 252 struck by lightning and burned. This indicates nearly as many buildings struck by lightning as were burned from any cause, but that the number burned

Read at the Ohio Academy of Science Meeting, Columbus, Ohio, November 27, 1914.

by lightning was less than one-fourth of the total lost by fire. The loss on the buildings burned or damaged by lightning was about one-third of the total fire loss.

Loss by Lightning Largely in Rural Districts.—In the central part of the country the loss and damage by lightning is far greater in the country than in the cities. The Indiana Fire Marshal states that 75% of all lightning losses occur in the country, which contains but 47% of the population. Also that in 1913, 92% of all barns damaged by lightning were in the country and that 69% of all barn losses were total. The Ohio Fire Marshal says that of 416 lightning fires in 1913, 319 were in barns. One insurance agent in Missouri reports that in 17 years the losess due to lightning on barns has been $6,000 greater than by fire from other causes.

Lightning.—Lightning is an electric spark on a tremendous scale. It occurs between clouds more frequently than between cloud and earth. Flashes last from one-one-hundred-thousandth to one-five-thousandth of a second.

Damage by lightning is mechanical as well as thermal. Not only is damage done by main discharges, but currents are induced in near-by metal objects and conductors and these often produce additional damage. Fires may be started in inflammable material between two nearly parallel rods or wires by these induction effects. Cases cited are between a fan shaft and a drive shaft bearing in a flour mill. Also between wires on baled hay, and between telephone wires and a lightning rod, where it is stated that lightning will jump 10 to 15 feet between the lightning rod and telephone wire.

Lightning Rods.—There was a time when lightning rods were a fad and the lightning rod agent flourished in the land and waxed fat. Because the lightning rod agent insisted on accumulating the good things of the land too rapidly there soon came a second period when shot guns were kept loaded and within reach, because the lightning rod agent was more to be feared than the lightning. And this second period still obtains in some parts of this country today.

But the lightning rods that were up staid up and those that had been installed in an honest and correct manner apparently furnished protection, while all around them buildings were being destroyed by lightning strokes.

Fire protection agencies, appalled at the immense fire loss, have in more recent years turned to the lightning rod as a possible aid. Honest lightning rod manufacturing companies have insisted that properly erected lightning rods are a protection, and professors of physics have told us that lightning rods, when continuous from the moist earth to the top of buildings, must aid

materially in the quiet interchange of electricity that is constantly taking place between the atmosphere and the earth, and that the rods should lead a disruptive discharge safely to the earth.

As a result, lightning rods are being put up, especially on barns in the country districts and Mutual Fire Insurance Companies are raising the question as to their efficacy.

To aid in answering this question the writer was directed by the Chief of the U. S. Weather Bureau to collect information for the Annual Meeting of the National Association of Mutual Fire Insurance Companies held in Columbus, in September, 1914.

Letters were therefore sent out to Mutual Companies in nearly every state in the Union, particularly those in rural districts. A large number of replies have been received and these have been summarized in the attached table.

This table shows that in 1912 and 1913 about 200 mutual companies doing a business of fully $300,000,000, had 1,845 buildings struck by lightning. And of the number struck by lightning, 67 only were equipped with lightning rods.

Do Lightning Rods Prevent Lightning Strokes?—The best information obtainable indicates that 31% of the buildings insured by these companies were equipped with lightning rods. This being the case, the expectation would be that of the 1,845 struck by lightning, 31% or 572 would be rodded, but in fact only 67 had rods of any kind. The number struck is therefore only 10% of the expected number, and the efficiency of the lightning rod in actually preventing lightning strokes is shown to be 90%.

In a report covering the past 5 years, 51 different companies having nearly 95,000 buildings insured, had 660 buildings struck by lightning and only 21 of these had lightning rods. Fully 34% of their buildings are rodded, so the expectation would be that 34% of 660, or 224 would be rodded. In fact only 21, or 9% were rodded, showing that out of every 100 buildings struck by lightning, 91 of them were without lightning rods and only 9 had rods.

A table made up from 67 different companies in Missouri, Illinois and Ohio, showed practically the same efficacy. Five companies doing business in Illinois, Missouri, and Nebraska with over 18,000 buildings insured, with reports covering a longer period of years, the shortest being 13 years and the longest 25 years, never have had a building burned or even materially damaged by lightning that was equipped with a lightning rod. And they report over 50% of their buildings rodded. This is efficiency of 100%.

If we should omit the few companies who have had damage on rodded buildings, we would still have reports from over 100 Farm Mutual Insurance Companies with over 400,000 buildings

insured and with a total risk of not far from $300,000,000, most of them reporting for the years 1912 and 1913, quite a number covering the past 5 years, and 5 for between 13 and 25 years, with not one building ever burned or damaged to any extent by lightning that had a lightning rod on it.

These findings of the efficacy of the lightning rod in preventing lightning stroke are contrary to the general opinion, but they substatiate those by Professor W. H. Day, of the Ontario Agricultural College, as published in their Bulletin 220. His inquiry covered Ontario, Iowa and Michigan, and included the records for several years and found the efficacy of a lightning rod in preventing lightning stroke to be from 92% to 99.9%.

Damage to Rodded Buildings.—In addition to actually preventing the lightning stroke, the properly installed lightning rod is of very great value in preventing damage to a building when it is struck by lightning.

The table in this report shows that the total claims paid on farm buildings due to lightning in 1912 and 1913, was $336,171. Inasmuch as 31% of the buildings insured by these companies were rodded, we would expect a loss on rodded buildings of 31% of $336,171, or $104,213, but as a matter of fact the total claims paid by these companies by lightning damage on rodded buildings during the two years was only $12,788. In other words the actual loss was only 12% of what would have occurred if the lightning rods did not serve as a protection.

The total number of buildings burned by lightning in 1912 and 1913 as reported by these companies was 407, and of these only 9 were equipped with lightning rods, or only 2%. Of those struck that had rods only 5% were burned and the other 95% simply damaged. Showing that the danger of a building being burned by lightning that is equipped with lightning rods is exceedingly slight.

A further study of the reports sent shows that where the buildings were struck by lightning and damaged, but not burned down the average damage per building was less than $10 on those equipped with lightning rods and very nearly $200 per building where not equipped with lightning rods.

Imperfect Rodding.—In some of the cases where rodded buildings were burned or damaged by lightning, the rods were recently installed and appeared to be in good condition. But in a large number of cases the rods were known to have been in poor condition or improperly installed. Some of the rods were old and defective, some not properly grounded, in some cases the lightning entered the building on a clothesline, in others the lightning struck a nearby building and the fire was communicated to the rodded one.

The all important thing seems to be to have a **continuous** conductor from the highest points on the building to permanently moist earth beneath. The kind of material does not seem to be so important as to be sure of frequent inspection, good grounds, and constant care that there are no poor or broken joints, or rusted and broken sections. The general opinion seems to be that the rods should be fastened directly to the side of the buildings without insulators and that all heavy masses of metal like hay tracks, etc., should be fastened to the lightning rods.

The Installation of Lightning Rods.—While lightning rods should be carefully installed yet their erection involves no more wonderful or mysterious process than building a fence or digging a well.

The statement by some lightning rod agents that no one but a special scientist versed in all the laws of electricity should do the work of putting up lightning conductors, is about as sensible as to say that no one but a professor in geometry should be allowed to lay brick.

And not only that, but any professional in the lightning rod business who advocates that his system is the only one that is scientifically correct and reliable, while all others are worthless and dangerous, invites the suspicion that he is himself a faker and charlatan.

Iron rods have some advantages over copper, but iron should be used only where it will be frequently inspected and kept painted. A 3-8 inch seven-strand, double galvanized iron cable is recommended and may be put up by the owner himself. Copper conductors should be soft drawn in the form of either tape or stranded cable. The National Board of Fire Underwriters for Protection Against Lightning make definite recommendations as to kind and form of rods.

Summary of answers from Mutual Fire Insurance Companies, received by J. Warren Smith, in August and September, 1914. A copy of the letter is attached. The columns are numbered to agree with the questions:

ITEMS	*	1	2	3	4	5	6	7	8	†
For 1912	92	191,009	469	756	588	154	24	14	3	31
For 1913...	121	328,565	1,174	1,089	809	252	43	33	6	31
For 5 years...	51	94,797	465	660	456	155	21	11	1	34
Misc. ‡	‡	18,155	591	495	245	71	0	0	0	55

ITEMS	9	10	11	12
For 1912......	$173,343,000	$362,009	$137,590	$8,104
For 1913......	249,883,000	572,344	198,581	4,949
For 5 years......	63,026,000	185,963	71,442	270
Misc. ‡..........	6,771,000	159,920	48,252	0

*Total number of insurance companies reporting.

† Percentage of buildings rodded.

‡ Summary from 5 different companies covering a term of years, the shortest being 13 and the longest 25 years.

August 3, 1914.

CIRCULAR LETTER.

Dear Sir:—This letter is being sent to a large number of Mutual Fire Insurance Companies in the United States with the hope of being able to compile valuable statistics as to the efficacy of lightning rods on farm buildings.

The answer will be considered confidential and the only matter published will be averages from a large number of reports. The information collected is to be used in the preparation of a paper to be read at the September meeting of the National Association of Mutual Insurance Companies in this city. Therefore please give the questions early and careful attention and make the answers just as complete as possible, even at the expense of some labor.

Very respectfully,

J. Warren Smith,
Professor in Meteorology.

QUESTIONS	In Year 1913	1912	Average in 5 years
1. Total number of farm buildings insured by your company			
2. Total number of farm buildings burned from any cause			
3. Total buildings struck by lightning			
4. Total struck, only damaged			
5. Total struck that were burned			
6. Of those struck by lightning how many had lightning rods			
7. Of those struck and damaged only, how many had rods?			
8. Of those burned by lightning how many had rods?			
9. Please give total risks on farm buildings.			
10. Give total claims paid from all fire loss on farm buildings.			
11. Give total claims paid due to lightning.			
12. Give total paid due to lightning on rodded buildings.			
13. Do you make any reduction in rate on rodded buildings?			

If you have had any cases where rodded buildings have been burned or damaged by lightning kindly give any information that you may have as to the kind of lightning rod, when put up and whether in good condition.

Name and address of Company....................................

Date. . ...

WILD AND CULTIVATED CLOVERS OF OHIO.

Mary B. Linnell.

Fabaceae—Bean Family.
Sub-family—fabatae.
Tribe—**Trifolieae**—Clovers.

Stamens diadelphus, anthers all alike. Leaves with three leaflets, rarely with one leaflet; leaflets denticulate.

Synopsis of Genera.

I. Corolla falling off after blossoming; petal claws free.
  1. Flowers in heads or short racemes, seldom single; pod linear, curved or twisted.
    a. Pod linear, straight, or somewhat curved, often beaked. *Trigonella.*
    b. Pod mostly spirally twisted, sometimes curved, or kidney-shaped. *Medicago.*
  2. Flowers in elongated racemes; pods thick, almost spherical or obovate. *Melilotus.*

II. Corolla mostly drying up and persistent after flowering; petal claws either all or the four lower ones united with the stamen tube. *Trifolium.*

Key.

1. Petals united with the stamen tube, persistent; flowers in globose or elongated heads, or umbellate. *Trifolium.*
1. Petals free from the stamen tube, falling off. 2.
2. Flowers small, yellow or white, drooping; inflorescence an elongated raceme. *Melilotus.*
2. Flowers single, in pairs, or in a dense more or less elongated inflorescence. 3
3. Leaflets denticulate all around, seldom almost entire-margined; fruit linear, beaked, often somewhat curved. *Trigonella.*
3. Leaflets denticulate only at the outer end; fruit strongly curved or spirally twisted. *Medicago.*

Trigonella L.

Annual plants with yellow or blue flowers. Stipules united with the petiole at the base. Flowers linear, straight or curved.

1. **Trigonella foenum-graecum** L. Fenugreek.

Annual fodder plants; flowers single or in pairs; pod linear, many seeded. Introduced from Asia and cultivated for its aromatic, mucilaginous seeds, formerly employed in medicines and still used by veterinarians. The source of "Semen faenu graeci."

Medicago (Tourn.) L.

Herbs with small, yellow, or violet flowers in axillary heads or racemes. Leaves pinnately veined, the veins terminating in the teeth. Calyx-teeth short, nearly equal; standard obovate or

oblong; wings oblong; keel obtuse. Ovulary sessile or nearly so, 1–several ovuled; style subulate. Pod curved or spirally twisted, reticulate or prickly, indehiscent, 1–few seeded.

1. Leaflets oblanceolate, oblong, or obovate, usually much longer than wide; flowers violet, purple, or yellow, perennial. 2.
1. Leaflets broadly obovate, cuneate, or nearly orbicular, as broad or nearly as broad as long; flowers yellow, annual. 3.
2. Flowers violet-purple or bluish; pod very much coiled. *M. sativa.*
2. Flowers yellow; pod scarcely coiled. *M. falcata.*
3. Inflorescence usually 10-many flowered; pod without prickles; stem somewhat pubescent. *M. lupulina.*
3. Inflorescence less than 10-flowered; pod prickly. 4.
4. Leaflets more or less truncate at the tip, with dark spot or spots near the center; stem somewhat pubescent, especially at the top. *M. arabica.*
4. Leaflets rounded at the apex; stem almost glabrous; leaves not spotted. *M. hispida.*

1. **Medicago sativa** L. Alfalfa.

Perennial herb with much branching crown; stem 2¾ ft. high, ascending; leaves 1½ in. long, 1½ in. wide, with petiole; leaflets ½–¾ in. long, ¼–½ in. wide, obovate to oblanceolate, dentate especially near the apex; flowers violet or blue, on short racemes; pod twisted into 2 or 3 spirals. In fields and waste places. Rather general. From Europe.

2. **Medicago falcata** L. Yellow Alfalfa.

Perennial herb with much branching stem, 15–20 in. high, ascending; leaves 1–1½ in. long; leaflets ¾ in. long, ¼ in. wide; flowers yellow; pod scarcely coiled. Occasionally found in waste places. Native of Europe.

3. **Medicago lupulina** L. Hop Medic.

Annual; branching at the base; branches decumbent and spreading; roots fibrous; stem 1–1½ ft. high; leaves 2 in. long, 1 in. wide; leaflets ½ in. long, ½ in. wide, obovate, often decidedly cuneate at the base; flowers with peduncles 1½ in. long; flower cluster oblong; pod spiral. In fields and waste places. Native of Europe. General.

4. **Medicago arabica** (L.) Huds. Spotted Medic.

Annual; branching from the root; spreading or decumbent; stem 12–15 in. high; leaves 3–5 in. long, 1–1½ in. wide, petioled; leaflets 1 in. long, ¾ in wide, obcordate, with purple spot on the mid vein nearer the apex than base; flowers yellow; inflorescence 3–5-flowered; pods spirally coiled, with curved prickles.

5. **Medicago hispida** Gaertn. Toothed Medic.

Annual; branching from the root; spreading or ascending; stem 15–20 in. high, glabrous; leaves ¾ in. long, ¾ in. wide, petioled; leaflets ½ in. long, ½ in. wide, obovate; flowers few, yellow; pod several seeded, spirally twisted and armed with curved prickles. In waste places. Lake County. From Europe.

Melilotus (Tourn.) Mill.

Annual or biennial herbs with small white or yellow flowers in slender racemes. Calyx-teeth short, nearly equal; standard obovate or oblong; wings oblong; keel obtuse. Ovulary sessile or stipitate, few-ovuled; style filiform. Pod ovoid or globose, straight, indehiscent or finally 2-valved. Seeds solitary or few.

1. Flowers white. *M. alba.*
1. Flowers yellow, sometimes pale. 2.
2. Stipules with entire margin; lateral petals as long as the standard or barely shorter. 3.
2. Stipules toothed at the base; lateral petals as long as the keel, but definitely shorter than the standard. *M. indica.*
3. Leaflets rather closely serrate; pod glabrous or glabrate, prominently cross-ribbed. *M. officinalis.*
3. Leaflets sub-entire or remotely toothed; pod pubescent, obscurely recticulate. *M. altissima.*

1. **Melilotus alba** Desv. White Sweet-clover.

Erect or ascending; branching; stem 3–10 ft. high, glabrous, leaves petioled, 2½ in. long, 1½ in. wide; leaflets 1½ in. long, ½ in. wide, oblong, serrate, narrowed at the base and apex; flowers in racemes, 5–8 in. long, white; pods ovoid. In waste places. Native of Europe. General and abundant.

2. **Melilotus indica** (L.) All. Indian Sweet-clover.

Erect, branching from the root; stem 17 in. long; leaves petioled, 1¾ in. long, 1 in. wide; leaflets ¾ in. long, ¾ in. wide, oblong, serrate, rounded at the apex; flowers in racemes, yellow, small; pod gibbous.

3. **Melilotus officinalis** (L.) Lam. Yellow Sweet-clover.

Erect, usually tall; branching at the root; leaves 2 in. long, 1½ in. wide, petioled; leaflets ¾ in. long, ¼ in. wide, oblong, serrate, apex rounded; flowers in racemes, 4–4½ in. long, yellow. In waste places. Rather general. From Europe.

4. **Melilotus altissima** Thuill. Fall Sweet-clover.

Erect, usually tall, leaflets narrow, nearly entire; pods pubescent, gibbous.

Trifolium (Tourn.) L.

Herbs with purple, pink, red, white or yellow flowers in dense heads or spikes. Stipules united with the petiole. Calyx-teeth nearly equal. Petals commonly persistent, their claws more or less completely united with the stamen-tube. Ovulary sessile or stipitate, few-ovuled. Pod oblong or terete, often included in the calyx, membranous, indehiscent or tardily dehiscent by 1 suture, or by a lid, 1–6-seeded.

1. Flowers yellow. 2.
1. Flowers red, purple, or white. 4.
2. Leaflets all sessile, stipules linear. *T. agrarium.*
2. Terminal leaflet stalked, stipules ovate. 3.
3. Heads 20–40 flowered. *T. procumbens.*
3. Heads 8–15 flowered. *T. dubium.*
4. Inflorescence much longer than thick; calyx silky, its teeth plumose. 5.
4. Inflorescence a globose, oval, or ovoid head. 6.
5. Leaflets ovate or orbicular; corolla crimson, as long or longer than the calyx. *T. incarnatum.*
5. Leaflets linear or oblanceolate; corolla whitish, shorter than the calyx. *T. arvense.*
6. Flowers sessile or nearly so, in dense ovoid oval, or globose heads. 7.
6. Flowers pedicelled in loose, globose. umbel-like heads. 8.
7. Heads sessile or nearly so, having a leaf immediately below; stem hairy, especially when young. *T. pratense.*
7. Heads always with a distinct peduncle, stem smoothish. *T. medium.*
8. Leaflets narrowly oblong, plant villous; calyx silky, perennial. *T. virginicum.*
8. Leaflets oval or obovate. 9.
9. Calyx villous or with bristly hairs. 10.
9. Calyx essentially glabrous. 11.
10. Calyx-teeth herbaceous, deltoid-lanceolate, nearly equaling the corolla. *T. carolinianum.*
10. Calyx-teeth bristle tipped, shorter than the corolla. *T. reflexum.*
11. Heads 1 in. or more in diameter; peduncles usually 1–2 in. long' stoloniferous. *T. stoloniferum.*
11. Heads $\frac{1}{2}$–$\frac{3}{4}$ in. in diameter; peduncles 2–10 in. long. 12.
12. Ascending, not stoloniferous; peduncles less than 6 in. long; flowers pink or nearly white. *T. hybridum.*
12. Creeping, stoloniferous, peduncles usually more than 6 in. long; flowers white or pinkish. *T. repens.*

1. **Trifolium agrarium** L. Yellow Hop Clover.

Annual; ascending; $1\frac{1}{2}$–2 ft. high; leaves $1\frac{1}{2}$ in. long, $1\frac{1}{2}$ in. wide; leaflets $\frac{3}{4}$ in. long, $\frac{1}{4}$ in. wide, obovate or oblong, denticulate, rounded at the apex, narrowed at the base; peduncles axillary, 1 in. long; flowers in oblong heads; corolla yellow, becoming dry and brown with age. Along roadsides and in waste places. Ashtabula, Lake, Cuyahoga, Knox, Clermont. From Europe.

2. **Trifolium procumbens** L. Low Hop Clover.

Spreading or ascending; pubescent; stem 1–$1\frac{1}{2}$ ft. high; leaves 1–2 in. long, $\frac{3}{4}$ in. wide, petioled; leaflets $\frac{1}{2}$ in. long, $\frac{1}{4}$ in. wide, obovate, cuneate at the base, rounded at the apex, finely denticulate; peduncles $1\frac{1}{2}$ in. long; flowers yellow, heads 20–40-flowered. In fields and along roadsides. Lake, Cuyahoga, Ottawa, Franklin, Montgomery, Gallia. From Europe.

3. **Trifolium dubium** Sibth. Least Hop Clover.

Spreading or ascending; 10 in. high; leaves $\frac{1}{2}$ in. long, $\frac{1}{2}$ in. wide, petioled; leaflets $\frac{1}{4}$ in. long, $\frac{1}{4}$ in. wide, obovate, rounded at the apex, denticulate, cuneate at the base; peduncles $\frac{3}{4}$ in. long; heads 8–15-flowered; flowers turning brown with age. In fields and waste places. Lake County. From Europe.

4. **Trifolium incarnatum** L. Crimson Clover.

Annual; erect; branching; 12–20 in. high; leaves long petioled, 6 in. long, 2 in. wide; leaflets 1 in. long, 1 in. wide, sessile or nearly so, all from the same point, obovate, cuneate at the base, rounded at the apex; peduncles 1½ in. long; flowers in oblong heads; corolla crimson. In fields and waste places. From Europe. Rather general.

5. **Trifolium arvense** L. Rabbit-foot Clover.

Annual; erect; branching above the root; leaves 1 in. long, ½ in. wide; leaflets ¾ in. long, ⅜ in. wide, linear or oblanceolate, cuneate at the base, rounded at the apex; heads oblong or cylindrical; calyx silky; corolla whitish. In fields and waste places. Warren, Stark, Cuyahoga, Lake. From Europe.

6. **Trifolium pratense** L. Red Clover.

Perennial; branching, decumbent or erect; 2 ft. high; leaves 4½ in. long, 2 in. wide; petiole pubescent; leaflets 1¼ in. long, ⅝ in. wide, with short petioles, all from the same point, ovate or oblong, narrowed at the base, rounded at the apex, usually with a prominent light ornamental spot in the middle; heads somewhat ovoid; flowers red, calyx hairy. In waste places and meadows. General and abundant. Naturalized from Europe.

7. **Trifolium medium** L. Zig-zag Clover.

Perennial; ascending; 14 in. high; leaves 6 in. long, 3 in. wide; leaflets 1½ in. long, ½ in. wide, oblanceolate to ovate; flowers nearly sessile, bright purple.

8. **Trifolium virginicum** Small. Prostrate Mountain Clover.

Perennial; branched at the base, the branches prostrate, pubescent; leaflets ½–1½ in. long, linear, narrowly lanceolate or oblanceolate, obtuse, serrate, dentate; flowers in globose heads, whitish, crowded.

9. **Trifolium carolinianum** Mx. Carolina Clover.

Perennial; ascending or procumbent; much branched from the base; leaves ⅜ in. long, ⅛ in. wide; leaflets all from the same point; obovate, cuneate at the base, denticulate; flowers purplish.

10. **Trifolium reflexum** L. Buffalo Clover.

Annual or biennial; ascending; branching, 15 in. high; leaves 1½ in. long, ⅝ in. wide; leaflets ⅝ in. long, ½ in. wide, oval or obovate, cuneate, denticulate; flowers red with peduncles 1–3½ in. long. In meadows and ravines. Belmont County.

10. **Trifolium stoloniferum** Muhl. Running Buffalo Clover.

Perennial; branching, forming runners at the base; stem 15 in. long; leaves 6½ in. long, 2 in. wide; leaflets 1¾ in. long, 1½ in. wide, broadly obovate; flowers white tinged with purple; pods 2-seeded. Prairies and dry woods. Hamilton, Clermont, Butler, Clinton, Clark, Franklin.

11. **Trifolium hybridum** L. Alsike Clover.

Perennial; erect or ascending; stem 3 ft. high; leaves 2–5 in. long, 3 in. wide; leaflets 1¼ in. long, ¾ in. wide, obovate, cuneate at the base, serrate; flowers pinkish. Open woodlands and waste places. General. From Europe.

12. **Trifolium repens** L. White Clover.

Perennial; branching at the base; branches creeping, often rooting at the nodes; leaves 5 in. long, 1 in. wide; leaflets 1 in. long, ¾ in. wide, cuneate at the base, denticulate, usually with a prominent white or reddish ornamental spot in the center; flowers white; pod about 4-seeded. General and abundant. Naturalized from Europe.

Essentials of College Botany—This new textbook by Dr. C. E. Bessey and his son E. A. Bessey, published by Henry Holt and Company, shows a decided advance over the senior author's "The Essentials of Botany" first published 35 years ago. In comparing the two books one cannot but be profoundly impressed with the great change that botany has undergone in this short period of time.

The book is well balanced in its presentation of the various fundamental subjects usually covered in the first course of college botany in America and should be found ideal for use in many colleges and normal schools. One of its highly desirable features is its modern presentation of plant classification, the authors having entirely discarded the antiquated systems still in general use. The phyletic arrangement given will certainly lead the student to a thoughtful study of plant relationships and the evolutionary processes which have brought about the system as one finds it in living plants. The reviewer can well remember some desperate struggles in attempting to harmonize the facts of morphology and evolution as an abstract principle with the classification which was in vogue when he first began the serious study of plants. The student who begins with the "Essentials" will experience no such difficulty and save time for a deeper study of the facts involved.

It appears that just as Bessey's original text presented a new phase in botanical study in America so will the present bock lead to a new and better method in the teaching of plant phylogeny and in the arrangement of plant groups and series in taxonomic work and systematic manuals.

J. H. S.

CELL DIVISION AND THE FORMATION OF PARAMYLON IN EUGLENA OXYURIS SCHMARDA.

L. B. Walton.

The method of reproduction in *Euglena oxyuris* Schmarda has not been observed, while the characteristic manner and the time element involved in the formation of the constituent parts of the cell is also of some interest. Therefore, the following notes made in connection with some uncompleted studies on the life cycle of Euglena are presented.

Of the forty or more species constituting the genus, *E. oxyuris* Schmarda is by far the largest, often attaining a length of approximately 500μ. In the study mentioned, several of the smaller species of Euglena had been observed by the writer, to encyst and after repeated divisions pass through an apparent sexual stage, in consequence of which it was desirable to check the results with a larger form, permanent preparations of which could be more easily made. Therefore, several specimens of *E. oxyuris* were transferred from a culture to a lens paper aquarium, the margins of which were closed by paraffin oil to prevent evaporation and placed under observation, Feb. 4, 1906. No reproductive processes similar to those in the smaller species mentioned were observed, but several in the process of division were noted and studied with the 1-12 immersion objective. The characteristie organs of the species (Fig. 1, A) are the oval nucleus (n), the large anterior (p^1) and posterior (p^2) paramylon granules, the stigma (s), reservoir (r), pharynx (p) and chloroleucites (c). The figures are all based on camera lucida drawings.

On Feb. 6, at 10:03 A. M., a single individual (Fig. 1, B) was observed much broader anteriorly than the normal form and in which the nucleus had approached the stigma while the anterior paramylon granule occupied very nearly the normal position of the nucleus. It was not until 1:45 P. M. (Fig. 1, C) that the division of the stigma was observed, the nucleus in the meantime having become obliquely elongated, and the anterior paramylon granule having moved down to a position beside the posterior granule. At 3:35 P. M. (Fig. 1, D) division had so far progressed that the anterior fourth of the individual—individuals?— were separated, the two nuclei being almost distinct. At 4:15 P. M. (Fig. 1, E) longitudinal division was nearly complete and the two nuclei were moving slowly posteriorly to their normal position. At the same time a peculiar phenomenon was taking place in connection with the two paramylon granules. The protoplasm containing the granule of the individual on the left would rapidly flow posteriorly, so that the granule was actually in the posterior end of the individual on the right as indicated by the solid arrow.

The time consumed was 20 seconds. Then the reverse flow occurred and the protoplasm containing the granule of the individual on the right would flow to the left as indicated by the dotted arrow. It would seem at times as if an observer could scarcely refrain from concern as to the probability that one individual would inherit all the paramylon. At 4:25 P. M. (Fig.1, F)

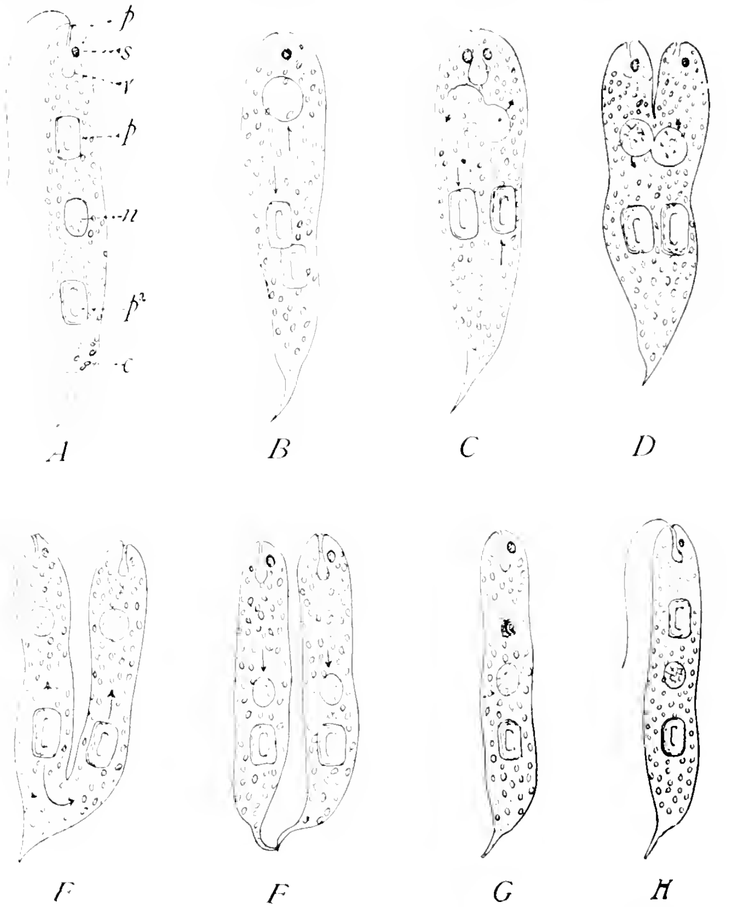

Fig. 1. (x 500). Cell division in *Euglena oxyuris* Schmarda and Formation of Paramylon. p=pharynx. s=stigma. p¹=anterior paramylon granule. n=nucleus. p²=posterior paramylon granule. c=chloroleucites.

the process of division was completed, the nuclei having moved posteriorly and the individuals appearing normal in every way with the exception that each lacked the large anterior paramylon granule. Observations were made periodically the follo ing day with the expectation of noting the development of the new

granule. It was, however, not until the succeeding day at 9:00 A. M. (Fig. 1, G), approximately 40 hours from the time of the complete division that an irregular, but distinct granule became visible. This gradually increased in size, but had not attained its full development at the end of the day, when the observations were brought to a close. The other twin individual had in the meantime disappeared.

There are two factors, however, which may have been instrumental in delaying the formation of the anterior granule, the lowering of the room temperature nearly to freezing at night, and the possible lack of the necessary nutrient material in the small closed lens paper aquarium.

While the synthesis of "paramylon," a term first suggested by Gottleib, (1851) because of the similarity in chemical composition to amylon (starch), normally occurs in connection with the chloroleucites present in the Euglenidae, the question as to its possible free formation as an assimilation product of the protoplasm has long been one of interest and one concerning which no definite statement may up to the present time be made. The mode of formation of the anterior paramylon granule in *Euglena oxyuris* is extremely suggestive, however, that the result is due to the activities of the protoplasm quite independently of the numerous small chloroleucites present. Distributed irregularly as they are throughout the cell body, it seems difficult to believe that their products should unite to make a structure so definite in form and position.

The time taken for the division of the individual was 6½ hours, with the assumption that the condition as figured in "B" had occupied only a brief period. Keuten (1895) notes the time of division in *Euglena virdis* as 3-4 hours. There are apparently no notes concerning the time necessary for division among other related forms, although Doflein (1911) gives a comparative table for various species of Protozoa. The factor is undoubtedly a variable one and largely dependent on the surrounding conditions particularly temperature and nourishment.

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Kenyon College, Gambier, Ohio, Dec. 24, 1914.

MEETING OF THE BIOLOGICAL CLUB.

ORTON HALL, May 4, 1914.

The meeting was called to order by Mr. Kostir and the minutes were read and approved. There was a discussion as to a possible time for a field trip. It was moved and seconded to have a committee to arrange a possible time and place for such a trip.

Prof. Vivian showed a long series of pictures illustrating his trip abroad. He began with pictures of Ireland and France. The most of the views were of India and Japan.

Miss Storer told of her eugenics work in the Field. She showed three charts, one of a Cleveland family and two of Rural communities. She showed that certain traits such as feeblemindedness, immorality, and alcoholism will run through an entire family.

A new cockroach, much like the Paleozoic Cockroaches was reported.

The meeting adjourned.

BLANCHE McAVOY, Secy.

THE FERNS OF ALLEGHENY COUNTY, PENNSYLVANIA—Professor Lewis S. Hopkins, of the State Normal School, Kent, Ohio, has published an admirable little manual of the ferns of Pittsburg and surrounding country, as Publication III of the Botanical Society of Western Pennsylvania. It gives not only the usual botanical information and keys for identification, but also notes on the fern haunts and habits and something of their folklore. It is profusely illustrated with half-tones remarkably true to nature. The beautiful habit pictures invite one alluringly to the woods. This is just the kind of booklet that is needed to lead the average person away from the nerve-racking life of modern times to the peaceful contemplation of nature. With this manual one should be able to identify most of the common ferns of Eastern Ohio. More books of this nature should be written.

J. H. S.

Date of Publication, February 12, 1915.

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ENTOMOLOGICAL WORK IN OHIO. *

HERBERT OSBORN.

Probably the first careful work upon insects occurring within the borders of Ohio should be attributed to Thomas Say, whose extended residence in Indiana made possible a study of many insects which were common to this region. While very few of these described species, twenty-six so far noted, were from specimens actually collected in Ohio, we may very fairly consider that all of the species credited to Indiana might be considered as common within our area. Says' residence from 1825 till his death in 1834 on the Wabash River at New Harmony, Ind., covered practically the same faunal conditions as are to be found in this state. Of the species described distinctly from Ohio the majority appear to be aquatic forms and to have been collected quite largely along the river; some of them, evidently, upon river boats which must have been the means of transportation at the time. Very few of the species recorded have economic importance.

Between the time of Say and up to the beginning of Experiment Station Work in the State there seems to have been a great dearth of Entomological Workers and very few records for Ohio insects appear in descriptive or faunistic papers. Among the persons in the state who gave attention to Entomology during this period we may note particularly Dr. Jared P. Kirtland who covered a wide range of Natural History subjects.

*Contribution from the Department of Zoology and Entomology, Ohio State University, No. 38.

Dr. Kirtland's work is worthy of special mention since it appeared at a time when but little attention was given to entomological matters and it appears from papers both in Entomology and Ornithology that he was a man of scientific attainments and his work of special merit.

He was a professor in the Medical College at Cleveland, but evidently a naturalist of the old school interested in all phases of natural history and making contributions to Botany Ornithology, Ichthyology and Entomology. His papers* in Entomology, as far as I can discover, appeared during the years 1838, 1841 and 1851–57. Several of them relate particularly to Ohio insects.

Another naturalist of a little later date, Mr. J. Kirkpatrick published a number of articles in the Reports of the Board of Agriculture, "Field Notes" and "Ohio Farmer," during the years 1855-68. Also an article on Grape Vine Flea Beetle, in "Field Notes," reprinted in Practical Entom., Vol. I, 1865, p. 40.

Mr. J. H. Klippart published a paper on the wheat plant including notices of its parasites, Cincinnati, 1860 and is credited with three articles in Field Notes, 1861, these being discussions with Mr. Walsh upon the life history of the army worm.

Prof. E. W. Claypole, first of Antioch, later of Buchtel College, a man with extremely broad acquaintance in all branches of Natural History, gave particular attention to the insects of the state. A number of articles in the Canadian Entomologist and other Journals are from his pen.

Prof. Wright of Oberlin gave some attention to collections but so far as I am aware published no papers which would be considered strictly entomological.

The work of Mr. Chas. Dury of Cincinnati, is worthy of special mention as his studies have covered a long period of time and have been of a very intensive character, especially with reference to Coleoptera. His papers have appeared mostly in the Journal of the Cincinnati Society of Natural History and constitute a very valuable contribution to the Entomological Literature of the state. Among his papers of special state interest are the Catalog of Coleoptera of Cincinnati and Lists of Lepidoptera for the same locality. He also has contributed largely to the material used by

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*Descriptions of new species of Libythea and Macroglossa. Family Visitor, Cleveland, Ohio, 1851, Silliman, Am. Jour. 1852, vol. 13, pp. 336-338.

An improved method of killing and preserving Lepidopterous insects for Cabinets specimens. Silliman, Am. Jour. Sci. 1852, v. 13, p. 286.

Diurnal Lepidoptera of the State of Ohio. Annals of Science, Cleveland, Ohio, 1854, Jan. p. 5, Feb. p. 45, Mar. p. 73.

On the Larva of the Thyreus Abbottii. Pr. Acad. Nat. Sci. Phila. 1857, p. 148.

Gordius aquaticus dans une Sauterelle. L'Institute, 1836, iv. p. 172-173.

Localities and Habits of certain species of insects. Silliman, Am. Jour. Sci. vol. xvii.

other workers and references to his collections may be found in reports on the Odonata by Kellicott, Diptera by Prof. Jas. S. Hine, Hemiptera by H. Osborn, and in other reports.

EXPERIMENT STATION ENTOMOLOGY.

Official Entomological work in Ohio may be considered as having started with the organization of the Experiment Station in 1882. While no official entomologist was connected with the Station at this organization it is interesting to note that quite an extended article was included in the First Annual Report of the Director, Prof. W. R. Lazenby, whose activity in Horticultural and Forestry lines has continued thru many years. The paper on insects in this First Annual Report occupies some twenty-four pages and discusses in general terms the nature of insect injuries and special remedies with discussions on the life history and habits with treatment for insects of the vegetable garden, the fruit garden, orchard and field crops.

Later reports of the station include references to insect studies, those up to 1886 apparently being under the direction of Prof. Lazenby, altho I understand that he was assisted in this work by Mr. Alwood.

In 1886, Mr. W. B. Alwood was given the title of Entomologist to the Station, and the Annual Report for the year 1886 includes a quite extensive paper by him. The first part is devoted to "Notes on Insects and Insecticides," and the second section under the title of "Injurious Insects" includes discussions of the better known and more common insects of orchard and garden. This report is in considerable part a compilation from the writings of Riley and other entomologists but includes references to Ohio observations and conditions. It must have served a very excellent purpose in furnishing information to the people of the state concerning the insects that are most troublesome here. Mr. Alwood* also reported to the Division of Entomology of the U. S. Department of Agriculture certain work on Ohio Insects.

Mr. Alwood's connection as Entomologist seems to have terminated at the end of the year 1886. The following report of 1887 contains no mention of insect work.

Soon after the reorganization of the Experiment Station under the National Experiment Station Act, Prof. C. M. Weed was appointed as Entomologist to the station, and since that time there has been no year without some official entomological work connected with the Ohio Station. Prof. Weed's studies concerned particularly the insects affecting fruits and his experiments and reports upon the remedies of plum curculio marked a distinct

*Report on Ohio Insects. Bull 13, Div. Ent. U. S. Dept. Ag. 1887.
Tests with Insecticides on Garden Insects, Bull 13, Div. Ent. U. S. Dept. Ag. 1887.

advance in that field. He also continued extended studies on the autumn life histories of Aphids and studies of certain aquatic insects. He also at this time was doing considerable work upon the Phalangidæ from the faunistic and systematic standpoint.

With Mr. Weed's transfer to New Hampshire in 1891, Prof. F. M. Webster was assigned to the Ohio Station, his relation being at first field agent for the Division of Entomology of the U. S. Department of Agriculture and his connection with the station altho incidental afforded him opportunity to publish studies upon the Ohio insects and to give the station the benefit of an experienced entomologist. This relation continued until 1892, when Mr. Webster was appointed Entomologist to the Ohio Station, a position which he occupied for a number of years—1892-1902. During this time he carried on some of his most valuable field studies and published a number of excellent papers.

The Bulletins which perhaps should be noted as of particular value are those related to the "Chinch Bug in Ohio," "Insects Affecting Wheat," "Insects Affecting Raspberries and Blackberries," "The Periodical Cicada in Ohio," "Reports Upon the San José Scale and Methods of Control."

Aside from his station reports he published a considerable number of papers in the Journal of the Cincinnati Society of Natural History and in various Entomological Journals.

Following Mr. Webster, Mr. P. J. Parrott served as state entomologist during the years 1902-1904, but left the position to accept that of entomologist with the New York Experiment Station at Geneva. Mr. Parrott's work dealt with studies of San José Scale and with applications for general treatment of insects and was marked by his vigorous method as apparent in his further work at New York.

He was succeeded by Mr. H. A. Gossard who has been in charge up to the present time and under whose management the department has seen a very marked growth, the staff of special workers, now numbering five, and the field covered being much wider than that possible with any of his predecessors.

INSTRUCTION IN ENTOMOLOGY.

As far as entomological instruction is concerned I do not find any indication of definite entomological courses being offered in any of the Ohio Institutions prior to the introduction of the course in Entomology in the Ohio State University by Dr. D. S. Kellicott in the year 1895.

Dr. Kellicott was a man of broad training, a graduate of Syracuse University, interested in many fields of entomology, an expert microscopist, a specialist in Protozoa, Rotifera, and Comparative Anatomy as well as an expert in Entomology and his course in Entomology must have been of very high grade.

According to the department statement of 1895-6 he offered a course in Zoology—4 (Entomology) bearing a credit of three hours in the third term of the second year of the short course in Agriculture. The description is—Lectures on the stages, anatomy and classification of insects. Will be followed by field work, with especial reference to economic entomology. A collection of 25 species of insects of economic importance will be required of each student.

Another course, Zoology 5, (Entomology,) carrying three credit hours for third term Junior year in Agriculture, and five hours a week for Juniors in Horticulture and Forestry. This was evidently an advanced course, as it specifies that the course is open to all students who have had Zoology I or its equivalent. The description is "First few weeks of the term there will be three lectures a week on the Morphology and systematic position of insects; the remaining weeks will be largely given to collecting, preserving, identifying, studying habits and methods of destroying injurious species. A collection of fifty species correctly set and named will be required of each student."

There was offered also Zoology 6, Advanced Entomology, carrying three or five credit hours thru the year. Described as "open to all who are prepared for it."

It is a matter of some interest to note that even at that time the course in entomology for the students of the long course in agriculture required a year of Zoology as preparation. This plan has been retained up to the present time and I believe is an excellent feature and one which is in part responsible for the excellent work that the students can accomplish in economic entomology.

Prof. Kellicott's Odonata of Ohio remains an important treatise on the group.

With the year 1895 and following Prof. Kellicott was assisted by Mr. J. S. Hine whose work has continued up to the present and whose many contributions on the Diptera and other groups of insects have been an important addition to the knowledge of the fauna of the state.

After the untimely death of Prof. Kellicott in 1898 the speaker was elected to the position made vacant on the staff and the organization of the department has undergone but little change except for the natural growth of the succeeding years since that time.

In recent years courses in Apiculture, Medical Entomology, Forest Entomology, Entomological Literature and Taxonomy have been added.

In 1912 a distinct four year course in Applied Entomology was projected, adopted by the College of Agriculture and students in this course commenced work in the following year 1913-14. Three students in this course, are candidates for the degree of B. Sc. in Entomology this year.

THE LAKE LABORATORY.

A feature of the work which may be mentioned here was the organization of a Lake Laboratory at Sandusky, Ohio. This was first established under the direction of Prof. Kellicott in 1895, and served as a research station for advanced students and instructors but without definite courses of instruction.

In 1900 the Laboratory organization was modified so as to provide for courses of instruction and since that time summer sessions have been held with a staff of various instructors from institutions in Ohio or adjacent states. Courses in Entomology have been offered as part of the regular curriculum. The Laboratory provides opportunity for a considerable amount of research work, and investigation of problems of insect life have their place among other studies undertaken there.

STATE INSPECTION OF ORCHARDS AND NURSERIES.

The state inspection of Nurseries was first provided for in connection with the Experiment Station and Prof. Webster was the official inspector during the years 1900-1902.

In 1902 under provision in the state laws the work of inspection was transferred to the Department of Agriculture and Mr. A. F. Burgess was appointed as the first official inspector. Mr. Burgess' work was of a very high character and at once commanded respect of Entomologists in other states and may be considered as one of the influences in developing a higher standard for this work thruout the country. His service terminated in the year 1907, and after a short interim the position was filled by the appointment of Mr. C. W. Mally, once assistant to Webster in the Ohio Station, and who had been for several years assistant to the government entomologist of South Africa. His connection with the inspection service in Ohio lasted only for about one year as he was recalled by a flattering offer from the South African government where he is still engaged. On his departure Mr. N. E. Shaw received the appointment (1908) and still remains the chief of the inspection service with a capable staff of inspectors.

BIOLOGICAL SURVEY.

As far back as in 1838 with the publication of Dr. Kirtland's papers on Ohio Animals the desirability of a Zoological Survey was urged and we find this idea prominently mentioned in the Volume on Zoology and Botany published in 1882. Dr. Newberry in the introduction of that report says "It is possible also that there are some who will fail to appreciate the value of these detailed reports on the Natural History of the State; but with the exception of some scattered newspaper or magazine articles, nothing has been published in regard to the Zoology of Ohio since the catalog prepared by Dr. Kirtland was issued in 1838, and in that interval

there has been felt a constant want in every town, village, hamlet, and farmhouse of a better knowledge of the surrounding objects of nature. In every district school questions are constantly arising, inspired by the natural curiosity of the child, which the teacher has not been able to answer, from the want of means of information in regard to the animals and plants of the State. An interest in nature is almost universal, and its development wholesome and happifying. Hence, the destribution of documents that will enable every one to learn the character and history of the objects that surround him, will prove not only a gratification but a benefit to a great multitude. All this for the educational influence of such reports. Their bearing upon the practical life of our people is not less real, since a knowledge of the habits of the animals that contribute to the support of man, the birds of the air, the beasts of the field, the fishes of the water, will be of great service as a guide in all efforts to increase the productiveness of these sources of aliment."

This volume of the Geological Survey included only reports upon the vertebrate animals but calls attention to the intention that reports upon the lower animals would be forth-coming in later volumes. This expectation was not realized and altho the desirability of a Biological Survey was recognized and urged at various times no systematic work in this connection was undertaken. The many contributions in this line came thru the work of the Experiment Station and from individuals, members of the Ohio Academy of Science or entirely independent workers. Recently, however, and as result of efforts of the State Academy of Science, a Biological Survey has been inaugurated in the University with the co-operation of a number of Ohio Institutions, and it is hoped that means will be available to push forward the studies on the state fauna and flora. Naturally some part of these must be entomological and, since the reports of the Geological Survey and a number of earlier papers have dealt especially with vertebrates, it will be but natural that the groups of insects will be treated as opportunity offers. From the great number of species and the prominence of the group it must result that considerable time and co-operation of a large number of workers will be necessary to make such a study in any degree complete. A Bulletin on the Syrphidæ of Ohio has already been issued and work upon Orthoptera, Spiders, Odonata, Coccidæ, Hemiptera and some other groups is in contemplation or under way.

CO-OPERATIVE EFFORTS.

The recent steps toward unifying Entomological work are so freshly in mind that a brief statement only seems necessary to indicate the present status. With the organization of the Agricultural Commission there seemed to be an opportunity for a co-

ordination or correlation of the work in this line carried forward under different agencies, and a conference of the heads of the several departments resulted in an agreement that certain recommendations to the Agricultural Commission would be desirable. Being assured by the Commission that such an effort would be entirely acceptable, a statement of the lines of co-operation which seemed desirable was presented to the Commission and later, on invitation, the whole matter was discussed in conference with the Agricultural Commission with an agreement upon the recommendations made.

The provisions of these recommendations were in brief to provide for conferences and co-operative work among the different Entomological workers to distribute lines of work with reference to securing highest efficiency, to avoid duplications and unnecessary expense in time and travel and to arrange for an annual meeting at which reports of progress, comparison of results and discussion of future projects might be considered. It is under this provision that we meet today in what it is hoped may be only the first of many annual gatherings.

What this co-operation means in the development of Entomological work in the State of course remains to be seen but that it is a basis for more effective and satisfactory work seems certain and as one result of this action we have this meeting and conference and feel very confident that an understanding of the problems being studied by the different individuals will result not only in a greater appreciation of the work being done by others, but will make possible such an interchange of ideas and opportunity for assistance as to stimulate and advance the Entomological work in the state.

It may be noted in a general survey of all of these state activities that whereas twenty-five years ago a single entomologist was responsible for all of the entomological duties of the state, there are now some seventeen different trained entomologists who give a large part of, or their entire time to this particular line of work and it is very apparent to all of us that the entomological problems pressing for solution are just as numerous and urgent today as a generation or century ago.

Another very marked feature is that whereas in the earlier days the work and reports of the entomologist were received with little confidence and even with contempt by most cultivators, the attitude at present is one of anxious attention to everything that can be suggested in the way of practical measures for insect control.

FORECAST.

The outlook for Entomological work may be considered as never more favorable and the opportunities in this line are strikingly shown in comparison with conditions a quarter century or more ago. My own recollection covers the development of practically all the methods of insect control, dependent upon the arsenical poison methods and fumigation, of quarantine, inspection and largely those measures which are connected with the rotation of crops based upon certain definite conditions in development or habit which make such control possible.

Looking ahead it may be pretty confidently predicted that Entomological Science especially that part which is particularly concerned in the control of injurious insects must undergo a great development and that the recognition of Entomological work must increase from year to year.

Along the lines of development which seem now to be especially promising are those based on studies of insect ecology, insect reactions and migration. While the use of arsenical poisons has reached a high degree of perfection it seems that these should be considered rather as temporary measures and that just as rapidly as possibly they should be replaced by control measures which do not necessitate the use of compounds which present such a degree of danger in their common use. The possibilities in the development of control measures based upon the use of repellants, or baits seem to deserve most careful investigation. This appears to me to be one of the fields in which there is opportunity for most valuable research.

The introduction of insect diseases and insect parasites is another phase which deserves continued investigation. While for some of the forms already tested the results have been discouraging, advantage has been shown in a sufficient number of cases to indicate that further study is needed for the determination of those fungi and bacteria which may be amenable to artificial control and especially the continued experiments with the transportation or introduction of parasitic insects for the checking of species not otherwise readily controlled. Along the line of adjustment of farm and orchard methods there is a large opportunity for more precise determination of the dependence of insects upon certain crop conditions and the adjustment of cultural methods to circumvent insect injury.

Especially along the line of exclusion of menacing insects of other countries there is opportunity for most careful study, a study which should cover the destructive insects of other portions of our own domain, also of adjacent countries and even those which are so remote as to offer litle direct opportunity for migra-

tion, since our modern means of rapid transportation offer abundant opportunities for introduction of injurious species thru commerce.

Some idea of the growth of Entomological Science may be inferred from the fact that thirty years ago the official workers in Entomology numbered not more than a dozen while today the number runs up into the hundreds. Something over five hundred are represented in Entomological Societies of this country.

Among the problems which are attracting Entomologists or Biologists there are numerous questions which depend for their solution upon the application of related Sciences. The development of special machinery involves the mechanician or mechanical engineer, the preparation of insecticides is largely chemical, preparation and formation of emulsions is a physical question, while any of the direct problems confronting the Entomologist involve plant or animal physiology in such manner that acquaintance with these branches of Science is almost essential. Furthermore acquaintance with principles of Agriculture and Horticulture lie at the foundation of so many of the methods of control that no Entomologist can feel himself qualified for economic work without some knowledge of these subjects.

It will be noted from this that while Entomologists must be specialists in the study of insects, they cannot by any means ignore general training in Science and Agriculture. The broader their preparatory work in these lines the better equipped they will be to recognize effective methods of application for insect control.

PUBLICATIONS.

Among the various Ohio publications which have served for the distribution of entomological matter are the Quarterly Journal and Review, Cincinnati, 1846; Annals of Science, Cleveland, Ohio, 1854; Family Visitor, published at Cleveland during the years 1850-52; Cincinnati Quarterly Journal of Science, 1874; The Ohio State Agricultural Reports; The Ohio Horticultural Society Reports; Proceedings of the Columbus Horticultural Society; The Ohio Farmer; Journal of Cincinnati Society of Natural History; Field Notes (1861); Ohio Naturalist, 1902 to present date; Ohio Geological Survey, 1838 and 1874; Ohio Academy of Science Proceedings, 1891 to date; Experiment Station Reports and Bulletins; Ohio Biological Survey and State Board of Health Reports.

Articles have also appeared in periodicals outside of the state such as Silliman's Journal of Science, The Canadian Entomologist, American Naturalist, American Entomologist, Journal of Economic Entomology, Annals of the Entomological Society of America, Entomological News, Psyche, etc.

ONAGRACEAE OF OHIO.

Rose Gormley.

Onagraceae. Evening-primrose Family.

Annual or perennial herbs, rarely shrubs, with alternate or opposite leaves without stipules, and with axillary, spicate or racemose, bisporangiate, epigynous flowers often with an hypanthium; sepals 2-6 (usually 4) rarely none; stamens as many or twice as many as the petals; ovularly with 1-6 cavities, styles united; ovules indefinite, usually anatropous; fruit, a capsule or small nut; seeds, small; endosperm little or none; embryo straight.

Synopsis.

I. Fruit a many-seeded capsule opening by valves or pores; cavities 6-4.
   A. Floral parts not on an hypanthium.
      1. Seeds naked; calyx persistent.
         a. Leaves alternate. *Ludwigia* (1).
         b. Leaves opposite; petals none or very small; stems creeping or floating. *Isnardia* (2).
      2. Seeds with a tuft of silky hairs; calyx deciduous. *Chamaenerion* (3).
   B. Floral parts on a prominent epigynous hypanthium.
      1. Seeds with a tuft of silky hairs. *Epilobium* (4).
      2. Seeds naked or sometimes tuberculate.
         a. Stamens equal in length.
            1. Ovules and seeds horizontal and prismatic-angled. *Oenothera* (5).
            2. Ovules and seeds ascending, not angled. *Raimannia* (6).
         b. Stamens unequal in length, one set longer.
            1. Ovules and seeds many. *Kneiffia* (7). *Hartmannia* (8).
            2. Ovules and seeds few. *Lavauxia* (9).

II. Fruit indehiscent; cavities 4-1.
   A. Floral whorls 4-parted. *Gaura* (10).
   B. Floral whorls 2-parted. *Circaea* (11).

Key.

1. Floral whorls with 4 or more parts. 2.
1. Foral whorls 2 parted. *Circaea* (11).
2. Without an hypanthium. 3.
2. Floral parts on a prominent hypanthium. 5.
3. Leaves alternate. 4.
3. Leaves opposite; stamens 4; flowers axillary. *Isnardia* (2).
4. Fowers in terminal racemes, purple or white. *Chamaenerion* (3).
4. Flowers axillary in ours, yellow or green. *Ludwigia* (1).
5. Plants acaulescent, stamens unequal in length; flowers in our species white or pink. *Lavauxia* (9).
5. Plants caulescent. 6.
6. Flowers yellow. 7.
6. Flowers white, pink or red. 9.
7. Stamens all of the same length; flowers nocturnal. 8.
7. Alternate stamens longer; flowers diurnal. *Kneiffia* (7).

8. Leaves undulate or toothed; ovules and seeds horizontal prismatic-angled. *Oenothera* (5).
8. Leaves sinuate or pinnatifid; ovules and seeds ascending not angled. *Raimannia* (6).
9. Leaves pinnatifid or lacinate, flowers $1\frac{1}{2}$-3 in. broad; buds drooping. *Hartmannia* (8).
10. Ovules numerous, ovulary narrow, elongated. *Epilobium* (4).
10. Ovules usually 4, one in each cavity, ovulary clubshaped, narrowed below, anther filaments with scales at the base. *Gaura* 10.

1. **Ludwigia** L.

Herbs, perennial or annual with alternate entire leaves, flowers, terminal or axillary; sepals usually 4, persistent; petals 4; stamens usually 4; capsule winged or with basal bracelets, dehiscent or opening by a terminal pore.

1. Flowers inconspicuous, sessile in the axis of the leaves, with small greenish petals; capsules not prominently ribbed or winged, valves separating from the terminal disk. *L. polycarpa.*
1. Flowers showy, peduncled, with large yellow petals; capsules prominently ribbed and winged, opening by an apical pore. *L. alternifolia.*

1. **Ludwigia polycarpa** S. & P. Many-fruited Ludwigia. Plants 1-3 ft. tall with entire, sessile, narrowly lanceolate leaves, $\frac{3}{4}$-$3\frac{1}{2}$ in. long; flowers small with minute greenish petals and acute triangular sepals; capsules. top shaped, with linear bractlets at the base, the valves separating from the terminal disk. Hocking, Cuyahoga, Auglaize, Lucas.

2. **Ludwigia alternifolia** L. Seed-box. Stems erect, 2-4 ft. high with short-petoled, entire, lanceolate, leaves 1-$3\frac{1}{2}$ in. long, flowers showy, with large ovate sepals and yellow petals of about equal length with the sepals; capsules, winged, opening by a pore in the apex. Lake, Fairfield, Cuyahoga, Muskingum, Erie, Defiance, Hocking, Lucas, Adams, Gallia, Brown.

2. **Isnardia** L.

Annual or perennial, prostrate or decumbent, herbs, creeping or floating, often rooting at the nodes; leaves opposite, entire, narrowed at the base; flowers axillary, sessile, often without petals; calyx top-shaped, 4—parted, persistent; petals 4 or none; stamens 4; ovulary with 4 cavities; stigma 4 lobed; capsule 4 angled; seeds numerous.

1. **Isnardia palustris** L. Marsh Purslane. Procumbent or floating herbs, glabrous, branched 4-15 in. long; leaves ovate, narrowing at the base $\frac{1}{2}$-$1\frac{1}{2}$ in. long; flowers solitary in the axils of the leaves, about $\frac{1}{8}$ in. broad; sepals 4, acute; petals, if present, reddish. Crawford, Summit, Ottawa, Knox, Hancock, Stark, Wayne, Madison, Lucas, Wyandot, Licking, Lorain, Lake, Franklin, Defiance, Geauga, Huron, Warren, Erie, Belmont.

3. **Chamaenerion** (Tourn.) Adans.

Perennial herbs with alternate, entire leaves, densely set on the stem; flowers showy, in terminal racemes; sepals 4, purple, linear, deciduous; petals 4 ovate, stamens 8, stigma 4-parted; capsule angled, dehiscent opening longitudinally, seeds tufted.

1. **Chamaenerion angustifolium** (L.) Scop. Fire-weed. Erect herbs 1½-8 ft.; leaves lanceolate, entire, 1½-5 in. long; flowers purple or white about 1 in. broad, capsules 1½-2 in. long, slender, white pubescent. Ashtabula, Stark, Lake, Medina, Erie, Cuyahoga, Williams, Summit, Geauga, Lorain, Defiance, Fulton.

4. **Epilobium** L.

Herbs with opposite or alternate leaves; flowers solitary, spicate, or racemose; calyx deciduous, 4 parted; petals 4, stamens 8, capsule long, slender 4-sided dehiscent longitudinally; seeds tufted with hairs.

1. Leaves entire, margins revolute. 2.
1. Leaves denticulate or serrulate; margins not revolute. 3.
2. Leaves narrowly linear, less than 1/8 in. wide, veins obscure; entire plant covered with white incurved hairs giving it a gray green appearance. *E. lineare.*
2. Leaves lanceolate 1/4 in. or more wide, veins evident; glandular pubescent hairs spreading. *E. strictum.*
3. Leaves narrowly lanceolate, 2-6 in. long; seeds obconic, beakless; coma red-brown. *E. coloratum.*
3. Leaves ovate-lanceolate, rarely over 2½ in. long; seeds ellipsoid, short-beaked; coma white. *E. adenocaulon.*

1. **Epilobium lineare** Muhl. Linear-leaf Willow-herb. Erect, perennial, much branched herbs 1-2 ft. high, the entire plant covered with white incurved hairs; leaves linear ½-1½ in. long, opposite or alternate, entire, margin revolute; flowers pink or white in the axils of upper leaves of the branches; capsules about 2 in. long. Erie, Clarke, Portage, Ottawa.

2. **Epilobium strictum** Muhl. Downy Willow-herb. Erect herbs 1-3 ft. high, pubescent with white spreading hairs: leaves sessile, lanceolate, ½-2 in. long, opposite or alternate, entire, flowers in the axils of the upper leaves of branches, ¼ in. broad, pink or white; capsules about 2 in. long. Licking County.

3. **Epilobium coloratum** Muhl. Purple Willow herb. Erect, branched herb, 1-3 ft. tall, somewhat canescent, often purplish; leaves narrow lanceolate, sharply dentate 2-6 in. long; flowers many, axillary, pink and white about ¼ in. broad, seeds obconic, beakless; coma reddish-brown. General.

4. **Epilobium adenocaulon** Haussk. Northern Willow-herb. Resembling the above species but leaves broader and rarely exceeding 2½ in. in length; seeds obovoid, short-beaked; coma white. Cuyahoga, Ashtabula, Defiance, Erie, Medina, Ottawa, Summit, Franklin.

5. **Oenothera** L.

Annual or biennial herbs, leaves alternate with sinuate or toothed margin; flowers yellow, in terminal spikes, hypanthium long and slender; petals and sepals 4; stamens 8; ovulary with 4 cavities; capsule 4-angled, opening longitudinally.

1. Hirsute-pubescent; upper bracts shorter than the ovulary, deciduous. *O. biennis.*
1. Velvety-pubescent; upper bracts longer than the ovulary, persistent. *O. oakesiana.*

1. **Oenothera biennis** L. Common Evening-primrose. Tall, erect, branched biennial herb, hirsute pubescent, 1-6 ft. high; leaves lanceolate, acute, denticulate 1-6 in. long; flowers yellow, borne in leafy bracts, 1-2 in. broad, capsule about ¾ in. long, hirsute, narrowed at the top. General.

2. **Oenothera oakesiana** Robb. Oakes' Evening-primrose. Plant resembling the preceding species but with velvety appressed hairs; leaves narrow, oblanceolate, dentate; flowers yellow 1-1½ in. broad. Erie County.

6. **Raimannia** Rose.

Annual, biennial or perennial herbs with prostrate or erect stems; leaves alternate sinuate or pinnatified; flowers, yellow axillary or sometimes in terminal spikes, nocturnal; hypanthium long, sepals 4; petals 4; stamens 8; ovulary with 4 cavities; capsule dehiscent longitudinally.

1. **Raimannia laciniata** (Hill.) Rose. Cutleaf Evening-primrose. Stem decumbent or erect, 4 in. to 2½ ft. tall; leaves deeply sinuate-dentate or pinnatified; ¾-2 in. long; flowers usually axillary, yellow; capsule linear ¾-1½ in. long, hirsute-pubescent. Cuyahoga County.

7. **Kneiffia** Spach.

Shrubby, annual or perennial herbs with alternate, linear, entire or dentate leaves, flowers yellow in terminal spikes or racemes; sepals and petals 4; stamens 8; stigma 4-cleft; capsules oval or clubshaped, 4 winged or angled, opening longitudinally.

1. Flowers ½ in. broad or less; hypanthium equal to or less than ovulary. *K. pumila.*
1. Flowers more than ½ in. broad; hypanthium longer than the ovulary. 2.
2. Plant hirsute with spreading hairs; capsule club-shaped. *K. pratensis.*
2. Plant softly pubescent; capsule oblong, not club-shaped. *K. fruticosa.*

1. **Kneiffia pratensis** Small. Meadow Sundrops. Erect, perennial, hirsute herbs 1½-3½ ft. high; leaves oblong-lanceolate or elliptic-lanceolate; flowers in terminal leafy-bracted spikes; capsules clubshaped, sessile. No specimens.

2. **Kneiffia pumila** (L.) Spach. Small Sundrops. Erect puberulent herbs, leaves oblanceolate to oblong; flowers, yellow, in terminal, leafy-bracted, spikes; capsules clavate, sessile or short stalked. Franklin, Ashtabula, Cuyahoga, Madison, Carroll, Washington.

3. **Kneiffia fructicosa** (L.) Raim. Common Sundrops. Erect pubescent herbs; leaves lanceolate to ovate, denticulate or nearly entire; capsule sessile or short stalked, oblong with prominent wings. Fairfield, Lake, Jackson, Wayne, Lucas, Muskingum, Trumbull, Cuyahoga, Belmont, Carroll, Stark, Portage, Crawford, Harrison, Hocking, Clarke, Lorain, Summit, Richland.

8. **Hartmannia** Spach.

Annual or perennial, erect or decumbent herbs with alternate pinnatifid or lyrate leaves; flowers in terminal spikes or racemes, drooping in the bud, white, purple or red; sepals 4, deciduous, petals 4, large; stamens 8; ovulary with 4 cavities; capsules clavate, 4 winged.

1. **Hartmannia speciosa** (Nutt.) Small. White Evening-primrose. More or less branched puberulent herbs, ½-3ft. tall; leaves lanceolate, pinnatifid or sinuate, 1-2 in. long, flowers white or pink, 2 in. broad; capsules ½-¾ in. long. Franklin County.

9. **Lavauxia** Spach.

Low herbs usually acaulescent sometimes with a short stem, basal leaves pinnatifid; flowers bisporangiate, white, pink, or pale yellow; sepals and petals 4; stamens 8; ovulary 4-angled, stigma 4-cleft; capsules sometimes winged above.

1. **Lavauxia triloba** (Nutt.) Spach. Three-lobed Evening-primrose. Perennial, nearly glabrous herbs; leaves, petioled pinnatifid or sinuate, oblong lanceolate, 1-8 in. long; flowers pink or white; hypanthium slender, 2-4 in. long; capsule as wide as long, about ½ in. long. Montgomery County.

10. **Gaura** L.

Annual, biennial, or perennial herbs, rather woody at the base, leaves, alternate, sessile; flowers bisporangiate, white, pink or red, in terminal spikes or racemes; hypanthium prolonged beyond the ovulary deciduous, sepals 4; petals 4 (sometimes 3); stamens 8; stigma 4 lobed; fruit resembling a nut, ribbed or angled, indehiscent.

1. **Gaura biennis** L. Biennial Gaura. Erect hairy or softly pubescent herbs, 2-5 ft. tall with lanceolate, acute or acuminate leaves; flowers white, turning pink, in long slender spikes; fruit sessile, ¼-⅜ in. long, 4-angled. Stark, Paulding, Montgomery,

Warren, Auglaize, Clinton, Adams, Union, Franklin, Shelby, Clarke, Richland, Madison, Green, Gallia, Clermont, Champaign, Fayette, Highland, Wayne.

11. **Circaea** (Tourn.) L.

Perennial herbs; leaves opposite, dentate; flowers white in terminal and lateral racemes; hypanthium extended beyond the ovularly, sepals 2; petals 2; stamens 2; ovulary with 1 or 2 cavities; fruit obovoid, indehiscent, bristly with hooked hairs.

1. Leaves firm, rounded at the base, slightly toothed; bracts none. *C. lutetiana.*
1. Leaves thin, cordate, strongly toothed; with minute bracts. 2.
2. Petals as long as the calyx; fruit 2-locular, bristly. *C. intermedia.*
2. Petals not so long as the calyx, fruit 1-locular, the hairs soft and tender. *C. alpina.*

1. **Circaea lutetiana** L. Common Enchanter's-nightshade. Erect finely pubescent herbs 1-2 ft. tall; leaves 1-4 in. ovate, acuminate, rounded at the base; flowers about ⅛ in., broad; fruit ⅛ in. long, bilocular, covered with hooked hairs. General.

2. **Circaea intermedia** Ehrh. Intermediate Enchanter's-nightshade. Plants 8-16 in. tall; leaves thin, ovate, middle and upper ones cordate, teeth salient; minute bracts usually present; petals as long as the calyx; fruit as in the above species. No specimens.

3. **Circaea alpina** L. Small Enchanter's-nightshade. Plant small 4-12 in. high, glabrate or pubescent, with ovate, coarsely dentate, leaves, usually cordate at the base, ½-2½ in. long; flowers about $^1/_{16}$ in. broad; fruit $^1/_{16}$ in. long with soft, hooked hairs, unilocular. Lorain, Summit, Hocking, Cuyahoga, Clarke, Ashtabula.

PECULIAR VARIETIES OF AMARANTHUS RETROFLEXUS.

JOHN H. SCHAFFNER.

The development of large numbers of new varieties from cultivated plants is a matter of general observation. The similar origin of varieties from species which are not under the control of man is still a question with some. However, that a great number of new forms appear in the wild state becomes evident whenever one begins to study a flora with which he is more or less familiar. A study of the varieties present in the weeds and other plants of our cultivated fields and gardens should be of some importance since we are here dealing with plants growing under like conditions as our domesticated species but which have not been subject to selection by man.

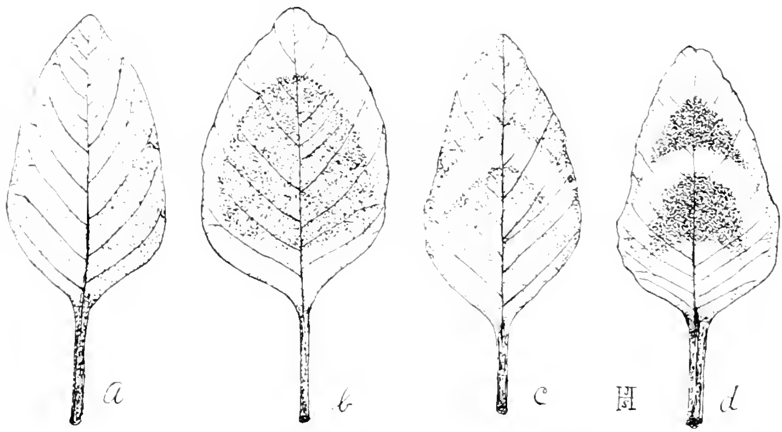

Fig. 1. Leaves of Amaranthus retroflexus.

The writer has made some study of our common weedy Amaranths and finds that there are a number of species showing distinct varieties. One of the most interesting of these is the common Rough Pigweed, Amaranthus retroflexus. This plant has a wide distribution in North America and is abundant in fields, gardens, and waste places. It is considered as an immigrant from tropical America, but whether in historical times or not is not known to the writer. The leaf characters of this plant are very diverse. There are different types of texture as well as markings. It is only the most striking of the leaf markings that will be considered here.

The usual leaf type of the species is the uniform green, showing no markings whatever except occasionally some red on the veins beneath. (Fig. 1 a). This form is the common type, according to the observation of the writer, from Ohio to Kansas.

Several years ago a neighbor was showing his garden and casually made a remark about the abundance of weeds. An Amaranthus retroflexus was present which had large, red, oval or ovate spots of anthocyan on the leaf blades. The spot was more prominent on some plants than on others but was of striking appearance in all of them (Fig. 1 b). Some of these plants were dug up and transferred to flower beds on the university campus. In the summer the spots disappeared so that it was difficult to identify the plants in September. However, in the spring great numbers of seedlings appeared with the characteristic leaf marking and they have been growing each year since. Other plants of similar nature were also observed in a corn field near Columbus. This form was looked for in various parts of Kansas but no specimens were found.

In Clay County, Kansas, a different type of leaf marking was observed on numerous plants growing together with the ordinary green type. This variety had a silvery, curved band a little beyond the middle, the curve being toward the tip somewhat similar to the silvery spots seen on the red and white clovers (Fig. 1 c). This silvery white patch is very persistent and appears on all of the leaves up to the inflorescence. No such plants have been observed at Columbus and none were found by the writer at Topeka, Kansas. Some seed was brought from the Kansas plants and produced the characteristic markings in a garden in Columbus.

The fourth striking pattern was also first observed on a farm near Morganville, Kansas. This type had the silvery curved band and a red spot on each side of it. (Fig. 1 d). Only three such plants were seen during a whole summer altho diligent search was made for others in the surrounding country. However, last summer this variety was found to be very common along the streets of Manhattan, Kansas, about forty-five miles from Morganville. This peculiar form appears as tho it might be a combination of "b" and "c". But as stated the red spot form was not observed in Kansas.

What is the significance of such patterns? It will be observed that the markings have no fundamental relation to the structure of the leaf. A utilitarian explanation would be out of the question. No hybridization is apparent and no related species are known in these regions which could represent possible parents. These patterns have been found to be hereditary and constant for several generations. Whether they are Mendelian is not known, no crossings having been attempted, as the flowers are small and

monecious and the difficulties of making pure pollinations would be considerable. They appear to represent definite mutations which developed without the influence of a determining environment and without the accumulative effect of a purposeful selection. One thing is certain. Among the weeds of the cultivated fields are species that are of the same complex composition, as regards characters and varieties, as those domesticated forms which have been subject to continuous hybridization and selection by man.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, October 5, 1914.

The first meeting of the Biology Club for the academic year was held on October 5 at its usual place in Orton Hall, with Mr. Kostir president. Following the nomination of Dr. Krecker and Mr. Markward for membership, it was moved and seconded that future meetings be held at the New Biology Building as soon as the necessary lighting facilities should be provided. The chair was then authorized to appoint three committees—one, for revision of the constitution; another, for nomination of officers; a third, to arrange for the Ohio Academy meeting. Reports on summer work followed.

Prof. Osborn gave some results of the work done by him at the Maine Experiment Station, on the life history of the Jassidæ (leaf hoppers) and Cercophidæ (frog hoppers) of that state. The long adult stage and gradual egg development were mentioned. Of special interest was the discovery of the fact that a species of Acocephalus has essentially a subterranean habit, feeding on the crown and roots of timothy.

Prof. Schaffner gave some observations upon the drought resisting qualities of a new variety of kaffir corn. Where other kinds would fail, this variety seemed little affected by the great lack of rain.

Prof. Landacre reviewed briefly his work relating to the nervous system of the shark, in which the details of defining the cranial nerves and marking out the ganglionic boundaries had been worked out.

Prof. Barrows reported several species of orb and triangle-weaving spiders collected by him in Hocking County. Many of these are distinctly southern forms, among which is Latrodectus mactans.

Miss Detmers had spent several weeks in working out the succession of forests in Northern Michigan. Specimens of spruce, showing interesting variations in the leaves were exhibited.

Mr. Metcalf reported results in spraying; Dr. Krecker, a large nematode parasite; Mr. Markward, transpiration experiments with wheat and corn; Mr. Drake, four species of Heteroptera new to the state; Mr. Lathrop, results of work in collecting Jassids in South Carolina.

Mr. Kostir reported an apparently new species of walking stick, also, an interesting species of Oecanthus. The may flies were found not so common as last year, and there were no box elder bugs at all in contrast with their great abundance of last year. He had given some attention to the glacial grooves about Cedar Point, some of which are very deep and distinct. He determined their prevailing direction to be N. E. by E. 70 degrees from north.

The members of the committees were announced:

(1) Nomination: Prof. Barrows, Prof. Landacre, Prof. Durrant, Prof. Griggs, Mr. Lathrop.

(2) Constitution: Prof. Barrows, Prof. Landacre,Prof.Durrant Mr. Drake, Mr. Meckstroth, Mr. Brown, Miss Mark.

(3) Ohio Academy: Prof. Osborn, Prof. Landacre, Prof. Seymour, Dr. Detmers, Miss Mark.

Meeting adjourned.

F. Brown, Sec'y. pro tem.

Orton Hall, Nov. 2, 1914.

The meeting was called to order by the President, Mr. Kostir, and the minutes of the previous meeting were read and approved. The President then called for reports of committees. Prof. Osborn stated that there had been two meetings of the committee which was assisting in the preparations for the meeting of the Ohio Academy of Science and that plans were almost completed. Prof. Barrows reported that the committee to revise the constitution was not quite ready to report as there was so much reading to be done and literature to be examined before the report could be handed in.

Dr. F. H. Krecker and Mr. H. W. Markward were elected to membership in the society.

The names of Dr. H. C. Brown, Miss Mary Oliver, Don B. Whelan, and D. M. DeLong were proposed for membership.

The following officers were elected for the coming year: Dr. R. J. Seymour, President; Miss Rose Gormley, Vice-President; Carl J. Drake, Secretary.

The newly elected President then took the chair, and the address of the retiring President, Mr. W. J. Kostir, on "Present-day Views on the Origin of Life" was the program of the evening. This was followed by a discussion of his address and the meeting then adjourned.

Carl J. Drake, Secretary.

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THE INHERITANCE OF SIZE IN TOMATOES.*

FRED E. PERRY.

INTRODUCTION AND STATEMENT OF PROBLEM.

Only within the last decade has the attention of students of heredity been turned toward the solution of the problem of the inheritance of quantitative characters. From the very beginning of the science of genetics qualitative characters have been studied until, by means of a series of brilliant discoveries, our knowledge of their inheritance has increased in a wonderful manner. Very little progress has as yet been made, however, in the study of quantitave characters and the inheritance of them has been exceedingly difficult to analyze.

Our present knowledge of heredity has been gained from a microscopical study of the germ-cells, from a statistical examination of data bearing on heredity and from the experimental breeding of plants and animals. The last of the above named methods of studying heredity has been chosen for this work on the inheritance of size in the tomato.

Size is a general term which means the measurement or extent of a thing as compared with something else or with a standard. It is applied to all kinds of dimensions great or small. The volume of a body is equal to the number of cubic centimeters which it contains; it is the amount or measure of tridimensional space. The mass of a body is defined as the quantity of matter

*Contribution from the Botanical Laboratory of the Ohio State University, No. 87.

which it contains. This definition of mass assumes that the quantity of matter is determined by the effect of force upon it. The weight of a body is the force with which the earth attracts that body. It is the measure of the mutual attraction between that body and the earth. The weights of bodies are proportional to their masses at any given place on the surface of the earth.

The tomato fruits are of a very irregular shape as they vary in every degree from a flattened spherical to a nearly perfect spherical, egg, plum or pear-shape. Not only do the various species and varieties differ widely from each other with respect to shape, but there is also considerable variation within the limits of each variety, which fact is especially noticeable when the large, cultivated tomatoes are considered. The large, flattened spherical or cup-shaped tomatoes, like Ponderosa or Livingston's Beauty, are very irregular in shape with many depressions and rounded projections. The long, pear-shaped tomatoes vary especially with respect to length, thickness and breadth of neck. Some fruits have distinct depressions at both stem and distal end while othe fruits have protuberances at these places. A tomato with these protuberances may have the same linear dimensions as a tomato with depressions but yet be of a very different size; or a pear-shaped fruit may have identical linear dimensions with an egg or plum-shaped fruit and yet there be a great size difference. It can thus be readily seen that it is impossible to get a good conception or estimate of the size of a tomato fruit from its linear dimensions.

It is not probable that the specific gravity of the cellular tissue of the fruits varies to any great extent. At least the variation of specific gravity would be reduced to a minimum within a certain definite variety. Since linear dimensions cannot give a true conception of the size of fruit and since there is but little variation probable in the specific gravity of the fruits, it is evident that the weight of a tomato fruit is the best possible index of its size.

Tomatoes are well adapted to the study of inheritance. The cross-breeding of the different varieties and species is comparatively easy and the plants may be readily propogated in a vegetative way. The tomato contains many heritable units, the inheritance of which may be studied. The plants are hardy; they grow without difficulty and mature normal fruit readily under greenhouse conditions.

In spite of the remarkable adaptation of the tomato to work in inheritance of size or weight, no such accurate work has been done with this fruit. A number of men have performed experiments upon the inheritance of the qualitative characters of the plant and fruit. Groth seems to be the only one who has worked with the inheritance of quantitative characters of fruit and he has been studying such characters as the linear dimensions and

number of locules. He has taken no weights and from weights alone, it appears to the writer, can accurate data be secured to show the inheritance of size.

This problem in genetics was undertaken with tomatoes because of their remarkable adaptability to work in heredity and because no work had been previously done with them along this line; and it was hoped that some contribution might be made to our scanty store of knowledge regarding the inheritance of quantitative characters—especially the inheritance of size.

MATERIALS AND METHODS USED.

Three crosses were made between pure lines of tomatoes in the greenhouse of the Ohio State University. The first cross was made (1911) between the little red currant tomato, Lycopersicon pimpinellifolium, and the yellow pear tomato, Lycopersicon lycopersicon (Lycopersicon esculentum). In this cross L. pimpinellifolium was used as the staminate parent and L. lycopersicon as the carpellate parent. The reverse cross-pollination was made many times but fertilization never occurred. The second cross was made (1912) between Livingston's Beauty (carpellate parent) and the Yellow Pear (staminate parent). The third cross was made (1914) with Livingston's Beauty as the carpellate parent and Bonnie Best as the staminate parent. It is to be noted that the first cross was made between species while the second and third crosses were made between varieties of L. lycopersicon. All of these pure lines with their hybrids have been growing in the greenhouse and results have been obtained, but completed data is now at hand from only the first cross and this paper will deal almost entirely with results obtained from this hybridization.

These cross-pollinations were made with the utmost care and every precaution was taken to provent the presence of any undesired pollen grains. Two unopened flowers of the same age were selected—each one on a plant of the pure line to be crossed. A capsule of paraffined paper was placed over the staminate bud and both ends were tightly filled with cotton so that the entrance or escape of pollen was absolutely prevented. A tag was attached to the stem of the flower to serve as a means of identification. The sepals, petals and stamens of the carpellate bud were carefully cut away with sterilized pollinating instruments; the stigma was examined with a hand lens to be sure that no pollen grains were present, and the gynecium was capsuled and tagged. After three or four days both capsules were removed and pollen from the stamens of the staminate flower was transferred upon a sterilized glass slide to the stigma of the carpellate flower. Then the pollinated gynecium was capsuled again and left for about a week until fertilization had taken place and the young fruit had begun to enlarge. All the pollinating instruments were carefully sterilized over an alcohol flame, both before and after they were used.

In addition to three crosses above mentioned, a large number of self-pollinations was made according to this method. Of these self-pollinations about 75 were successful. The chances of cross-pollination were small because of the distance between the plants and the absence of insects; but it was considered necessary to have as large a number of self-pollinated fruits as possible to serve as a comparison with other fruits and to furnish pure seed for new cultures of plants.

The soil in which the plants were grown was uniformly of the same composition, as it consisted of two-thirds of greenhouse soil and one-third dry compost. This greenhouse soil was built up after years of experimentation to secure a soil of ideal physical condition for use in pots. The dry compost, which was used, was composed of one-third blue grass sod, one-third leaves and one-third dairy stable cleanings. The greenhouse soil and compost mixed together in the proportions given above, were found to produce a soil ideally adapted, both physically and chemically, to the growth of tomatoes in pots.

The tomato seeds were first planted in a pot of sterilized soil. After the young plants had attained a sufficient size each one was transplanted to a separate two- or three-inch pot. As the plants grew larger they were placed in pots of a greater size until they all came to maturity in the uniform five-inch pots.

These pots were placed from 18 to 24 inches apart in a long row on the benches in the greenhouse. Small bamboo rods about three feet in length were forced horizontally into the soil of the pots and the plants were tied to these supports with raffia. The tops of the upright bamboo rods were fastened with raffia to a long spliced bamboo rod which ran above and parallel to the pots and surface of the bench and which was firmly fastened to upright iron posts that braced the roof of the greenhouse. In this manner ample support was given to the plants even when ladened with fruit.

As soon as the fruits ripened they were gathered and carefully weighed on a pair of accurate balances. A fruit that has been picked for several days will be found to have lost weight by transpiration of water. A ripe fruit that has been allowed to remain on the vine until it has become soft and started to decompose will also give a diminished weight. Every precaution was taken to avoid such diminutions of weight as the fruits were gathered as soon as they became ripe and they were always weighed immediately after they had been gathered.

After each fruit had been weighed the polar length and maximum and minimum equatorial diameters were measured with a pair of calipers. The number of locules was noted and the seeds were carefully counted and saved. The shape and color of fruit

were observed. All of this information was carefully recorded in the accession book, together with any unusual features which the fruit may have possessed.

A system of careful labelling was devised and each pot was labelled with an aluminum label by means of which the plant might be identified. The key to the labels was kept in the accession book so that at any time the exact pedigree and descriptions of ancestors of any particular fruit could be readily found. The danger of losing the identity of any plant or fruit was thus reduced to a minimum.

HISTORICAL REVIEW.

Mendel (1860–70) formulated his epoch-making law of heredity as a result of experiments on the inheritance of qualitative characters in garden peas. His results led him to believe that each character depended upon a single determiner or factor, for he worked on simple characters belonging to different parts of the plant. When two plants differing with respect to one unit character were crossed, the segregation in the F-2 generation was computed and found to be in the ratio of 3 to 1. Where there was a difference of two characters between the parents, the F-2 segregation resulted in the ratio of 9 to 7. The possibilities, which would occur when there was a difference of three characters between the parent plants, were computed and the results obtained by breeding came close to the theoretical explanation.

Mendel's law of heredity was rediscovered and rescued from obscurity (about 1900) by De Vries, Correns and Von Tschermak. Following the lead of these three pioneers of heredity, hundreds of other scientists did experimental work along the same lines, until the validity of this law with its three fundamental principles of independence of unit characters, dominance and segregation has been amply proven.

Not until within the last decade, however, was it discovered that the expression of some qualitative characters require the presence of more than a single, separately inherited determiner or factor. Bateson's work in 1908 with two strains of sweet peas (Lathyrus), Bour's investigation with the snapdragon (Antirrhinum) and Castle's experiments with guinea pigs have shown that the qualitative character—color—may depend upon the interaction of at least two gametic factors. East in 1910 (14) found two factors for the production of yellow color in the endosperm of maize. Emerson in 1911 (21) discovered two yellow colors in the endosperm of maize that seemed to be unlike in appearance. Nilsson-Ehle in 1909 (39) crossed a white and browned-glumed wheat and found two factors necessary for the production of the brown-glumed condition, as the F-2 generation segregated into the ratio of 15 brown to 1 white head, which was

the expected Mendelian ratio when two factors were required to produce the brown color. When he crossed a red and white-grained wheat, the F-2 generation segregated into the ratio of 63 red to 1 white grain. From this Nilsson-Ehle reasoned that three independent factors were required to produce the red color.

Although the operation of Mendel's law of heredity with respect to qualitative characters has been amply proven, there is a considerable doubt in the minds of many foremost geneticists as to whether or not quantitative characters are inherited in a Mendelian fashion. It has only been within the last few years that students of heredity have turned their attention to the problem of inheritance of quantitative characters.

The first man who worked definitely with quantitative characters seems to have been Lock in 1906 (36) who crossed a tall race of maize with a shorter race and obtained an F-1 hybrid intermediate in size between the parents. The F-2 plants showed no segregation when crossed with one of the parents. Lock showed that the height of a plant is not inherited in a simple Mendelian fashion.

Castle in 1909 (8) worked with the ear-lengths of rabbits and discovered what he called "blending inheritance". In summing up his own work Castle says, "A cross between rabbits differing in ear-lengths produces an off-spring with ears of intermediate length, varying about the mean of the parental ear-lengths. * * * * A study * * * * shows the blend of parental characters to be permanent. No reappearance of the grand-parental ear-lengths occurs in the F-2 generation, nor are the individuals of the second generation as a rule more variable than those of the first generation of cross-breeds. * * * * The linear dimensions of the skeletal parts of an individual approximate closely the mid-parental dimensions".

Ghigi in 1909 (22) crossed a Paduan fowl and a bantam and found that the size of body and eggs of the F-1 cross-bred individuals were intermediate between the parent races. Only a limited number of the later generations were grown and these showed no segregation of size characters.

Mendelians have not recognized the validity of any so-called "blending inheritance" except that which Castle has shown. And these results on the ear-lengths of rabbits have been explained according to the Mendelian notation by Lang, whose explanation is recognized as possible by Castle. Some Mendelians object to this "blending inheritance" on the grounds that the number of individuals grown was not large enough to prove that segregation does not occur in the F-2 generation and Castle has admitted the possibility of this fact.

The experiments of Phillips in 1912 (40) upon the inheritance of size in ducks were more extensive than the work of Castle or Ghigi. He crossed a Mallard with a Rouen duck and found that the F-1 birds were intermediate in size as compared with the parents. Segregation was present in the F-2 generation. Phillips concludes, "The amplitude of variation of the F-2 fowls is greater than that of the F-1 fowls but does not extend beyond the nearer limit of the respective grandparental races."

Nilsson-Ehle (1908) showed how the Mendelian notation for the inheritance of qualitative characters might be used as a basis for the explanation of the inheritance of quantitative characters.

East in 1910 (14) in ignorance of Nilsson-Ehle's 1908 paper, developed a similar theory and showed how certain data on the inheritance of the number of rows of grains on an ear of maize could thus be analyzed.

Emerson in 1910 (19) issued a paper on the inheritance of quantitative characters in Cucurbita pepo, Phaseolus vulgaris and Zea mays. He showed segregation of size factors but offered no Mendelian explanation.

Johannsen (32) crossed two lines of beans and worked with the inheritance of length and breadth. He found the F-1 generation intermediate between the parent biotypes. The F-1 beans were no more variable than the parents but no definite conclusions can be drawn from this fact as only a limited number were grown. The F-2 and F-3 generations showed greatly increased variability over that of the parent biotypes. The length of the parent beans differed widely from each other. Neither the F-1 nor F-2 generation reached the extremes in length of the parent biotypes but the F-3 generation did reach those extremes. The breadth of the parent beans were very similar. The F-2 generation exceeded in breadth the extremes of the parent biotypes, while the F-3 generation more widely overlapped those extremes.

Belling in 1912 (1 and 2) crossed two widely different bean varieties. The F-1 generation exceeded in size of seed and plant either of the parents. The F-2 generation showed marked variability.

East in 1913 (13) worked upon the corolla length of Nicotiana and found the F-1 hybrid corolla length to be the geometrical mean between the parent lengths. The F-2 generation showed greater variability than the F-1 generation.

Groth in 1912–13 (26, 27, 28 and 29) conducted extensive experiments upon the inheritance of tomato seedlings, leaves and fruits. He worked with linear dimensions and found the F-1 fruit to be the geometrical mean between the parental dimensions. Marked segregation of size occurred in the F-2 generation. His Mendelian explanation of the results is very complicated and will be discussed later in this paper.

Punnet in 1914 (44) conducted extensive experiments upon the inheritance of weight in poultry. He obtained an F-1 bird intermediate in size between the parents while the F-2 generation showed strong segregation. These experiments are still in progress. His latest report (February, 1914), says that the work is not yet advanced far enough to permit of complete analysis, "but the nature of the F-2 generation raised last year strongly suggests that size depends upon definite factors which exhibit ordinary Mendelian segregation."

In addition to the experiments above noted, other work of like nature has been done within the last few years. No definite results regarding the explanation of the inheritance of quantitative characters have as yet been obtained. Castle says (6) (March, 1914), "Although extensive observations upon the subject of size inheritance in both animals and plants have been made, they have resulted in the demonstration, as yet, of no single clear-cut Mendelizing unit character (or factor either)."

INFLUENCE OF ENVIRONMENTAL CONDITIONS.

The influence of environment in the present series of experiments may be considered under four heads.

Light. The growth of the plants was influenced not only by the intensity but by the duration of light. In the tomato plants, as in other species, assimilation commences with a certain minimum and increases as the intensity of the light rises until a certain optimum is obtained.

Light that is too strong is injurious. The period of ripening of the fruits was shortened in proportion as the optimum light intensity was reached. In the winter when both the intensity and duration were low the plants ceased to bloom but preduced normal fruits as long as they did bloom. There is no evidence to show that the light conditions present in the greenhouse in any way influenced the size of fruit.

Temperature. According to Warming (b), "Each of the various vital phenomena of plant-life takes place only within definite (minimum and maximum) limits of temperature, and most actively at certain (optimum) temperature; these temperatures may even differ in respect to the different functions of one species." From this it may be inferred that the lower greenhouse temperatures in winter may have had some influence in causing the tomato plants to cease to bloom, since the lower critical limits for reproduction, as with many other species of plants, is evidently higher than that required for growth. The various temperatures of the greenhouse (45° to 100° F.) came within the cardinal points for growth and, as far as could be ascertained, seemed to have no appreciable influence upon the size of the fruits.

(b) See (40) page 22.

MOISTURE. The noticeable lack of moisture will cause a plant to become ill-nourished and dwarfed. The moisture conditions in the greenhouse were controlled as perfectly as possible and the tomato plants were watered quite often, but even then optimum moisture conditions did not prevail. The lack of a constant abundance of water probably exerted a great limiting influence upon the size of plant. The transpiration of water is directly proportional to the amount of leaf surface and, after the plant has reached a certain mature size, the leaf surface becomes limited as the amount of moisture in the pots is limited. The plants grown in the garden attained a greater size than the potted plants and one of the principal reasons for this difference was the more constant and abundant supply of soil-water present in the garden environment. There was no corresponding influence upon the size of fruit, as there was no noticeable difference of fruit-size as a result of the different moisture conditions under which the plants were grown.

SOIL. The quantity and quality of the essential nutritive substances in the soil, as well as the physical condition, influences the size of a plant and fruit. Warming says (b), "Defective nutriment (that is an inadequate supply of one or more substances) may be the cause of dwarf-growth (nanism); this has been demonstrated by many physiological investigations." All of the potted plants in these experiments were supplied with a soil as perfectly adapted as possible, both physically and chemically, to the growth of the tomato. And yet, the amount of available plant nutriment in a five-inch pot is necessarily somewhat limited while the available nutriment substances are more abundant in the garden, so that this lack of nutriment in the pots together with the lack of perfect moisture apparently caused the difference in size between the greenhouse and garden-grown plants. There was not enough difference, however, between the soil and moisture conditions of the greenhouse and the garden to cause any appreciable change of fruit-size.

Two experiments were tried to determine the effect of different kinds of soil conditions upon the size of plant and fruit.

The first experiment was performed in order to show the effect of the garden conditions upon the size of plant as compared with the effect of the greenhouse environment upon the size of the same plant. In the garden the soil contained more available nutriment and moisture than were present in the pots. A number of plants of the F-1 generation (17–12 2) were grown in the greenhouse where they attained at full maturity a height of about 2.5 feet and a diameter of 1.5 feet. One of these plants was afterwards removed to the garden where it grew to be 3 feet high and covered

(b) See (40) page 56.

a circular space of ground about 10 feet in diameter. Unfortunately no fruits were weighed while the plant was grown in the greenhouse, but any increase in the size of fruit, as a result of the garden conditions, was so slight as not to be apparent.

The second experiment was completed in order to determine the effect of a soil which contained very little plant nutriment that was available, upon the size of plant and fruit. Plant 10 of the F-3 generation (17–12–4) grew in the greenhouse to be about 7 feet tall and possessed an average fruit of 2.22 grams. A cutting of this plant was grown in an eight-inch pot filled with pure, washed, desert sand which contained very little plant nutriment. An inch layer of normal pot-soil was added in the middle of the pot as it was feared the scarcity of nutriment would cause the plant to die before it reached maturity. The light temperature and moisture conditions were identical with both plant 10 and the cutting. The plant in the sand grew to be only 21 inches high and its average fruit weight was found to be .85 grams. The size of plant and fruit were reduced 75% and 61% respectively. This shows the effect of extreme lack of the essential nutritive substances upon the size of the plant and fruit.

In addition to the F-1 plant grown in the garden, as described in the first experiment, a number of other plants of the parental and hybrid generations of this currant-pear cross has been grown both outside and inside the greenhouse. Any effect upon the fruit, as a result of greenhouse environment, would probably be shown by a decrease in size. So far as can be ascertained, however, from all the evidence new at hand, there was no appreciable difference in the size of fruits as a result of the different environmental conditions of the greenhouse and garden.

Even if there were a small diminution in the size of the tomato fruit as a result of being grown in the greenhouse, this change of size would affect all plants in the same way and in the same proportion, and, as all the plants concerned in this problem are greenhouse grown, the accuracy of the ratio between the sizes of the parents and offsprings, which is the vital part of the thesis, would remain unimpaired.

The average weight of the first ten fruits of a plant was compared with the average weight of ten fruits taken in the latter part of the fruit bearing period. A number of plants were examined in this manner and it was found that the fruits which ripened first were not larger than those which ripened later, nor was any correlation discovered between the size and time of blooming. The relation between the time of blooming and the size of fruit on a single cluster was examined and considerable data collected but no correlation was found to exist.

FLUCTUATING VARIATIONS.

Any quantitative character is subject to deviation from the average condition. According to the laws of chance these deviations are sometimes plus and sometimes they are minus, as a result of which they have been termed "fluctuating variations". Quetelet has shown that all living structures vary and are always grouped about a mean. In other words plus or minus deviations of increasing magnitude occur with diminishing frequency in such a way that a given population will be distributed, in a large part, at or near this mean or mode. Galton called attention to this

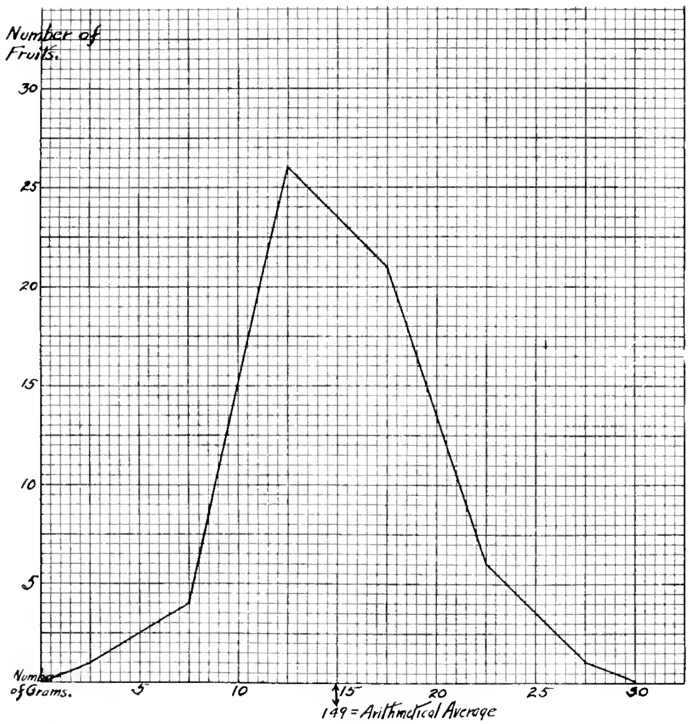


Figure 1

same fact in another way when he stated that the offspring of parents with plus or minus variations are closer to the average than the parents. There are always certain limits of fluctuating variability beyond which the deviations do not extend.

Since the fruit of the individual plants were found to be subject to these fluctuating variations in size, it was considered necessary to harvest a large number of fruits from two typical plants in

order to determine both the nature and degree of such variations. From plant 7 of the series 17–12–4 (F-3 generation) 58 fruits were examined. The curve formed by these weights is shown in Figure 1. The fruit-weights vary 2.35 grams. The mode is shown to be less than the arithmetical mean and therefore the skew is negative.

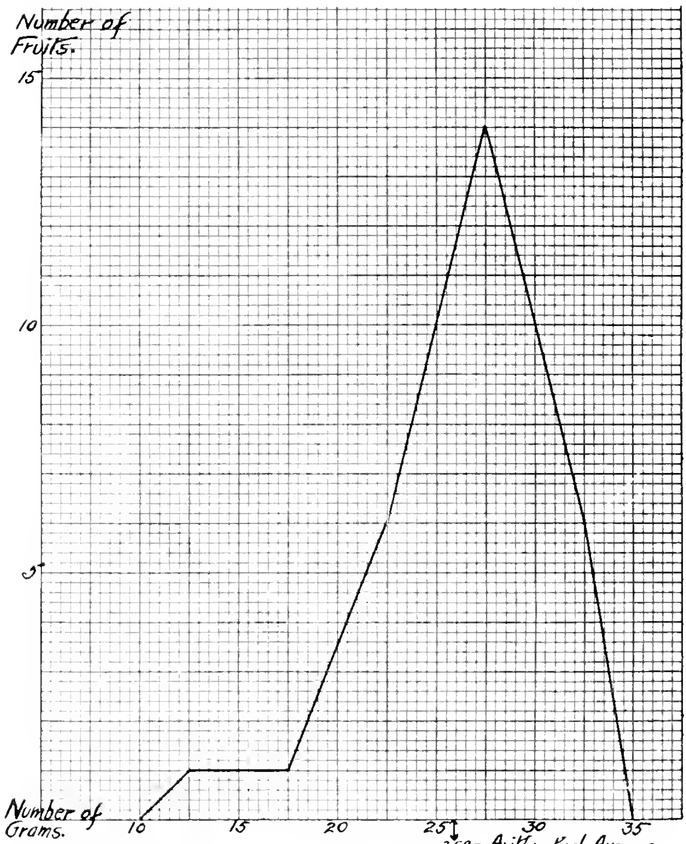


Figure 2

From plant 14 of the series 15–11–2—II–II (F-2 generation) 28 fruits were harvested and the curve formed by the weights of these fruits is shown in Figure 2. The fruit-weights vary 1.93 grams. As shown on this plate the mode is a little more than the arithmetical mean and therefore the skew is slightly positive.

The ideal plant fruit-size would have been obtained if it had been possible to harvest from each plant 1000 fruits or more and the modal average taken. As this could not be done, it was determined to select at least ten representative fruits from a plant, the arithmetical average of which would be considered the average fruit-size for that plant. In some cases, however, it was not possible to harvest at least ten fruits so that a few plants are represented by only four or five to nine recorded fruits. In the selection of the fruits to be gathered the greatest degree of care and accuracy was observed. One of the largest and one of the smallest fruits were first taken, after which the remaining fruits were selected as near to the mode of the fruit size as possible. It is believed that the deviation of the recorded fruit-weight of any plant, based on ten selected fruits, does not vary more than plus or minus .2 gram from the actual fruit-weight which would have been secured had all the normal fruits of that plant been harvested. But even if the error of plant fruit-size were twice that amount it would not materially affect the results of this work.

RESULTS OBTAINED.

The plants of the Yellow Pear tomato (carpellate parent) possessed the following average fruit-weights:

2-11-16.	Plant	2	=	19.26	grams.
"	"	3	=	17.84	"
"	"	4	=	12.71	"
"	"	5	=	17.84	"

The average fruit-weight of this parent pure line is 16.91 grams.

The variability of the average fruit-sizes of the plants of the Red Currant tomato (staminate parent) is very slight and fruits from only two plants were weighed. The following average fruit-weights were obtained from these plants:

7-11-2.	Plant	1	=	.66	gram.
"	"	2	=	.62	"

The average fruit-weight of this parent pure line is .64 gram.

The F-1 hybrid generation of this cross was found to be intermediate in size. The plants possessed the following average fruit-weights:

17-12-2.	Plant	1	=	1.90	grams.
"	"	2	=	2.48	"
"	"	3	=	2.22	"
"	"	4	=	3.46	"
"	"	5	=	3.76	"

The F-1 generation average is 2.76 grams. The geometrical mean between the weights of the parents is 3.28 grams which is only .52 gram more than the actual arithmetical mean of the fruit-weights. It is to be also noted that two F-1 fruits are

heavier than 3.28 grams while three fruits are lighter. There is thus a remarkable agreement between the geometrical mean and the actual generation fruit average.

There were four distinct series of F-2 plants grown. Each series was derived from a separate parent F-1 plant or fruit. The following table shows the average fruit-weights of the plants of the F-2 series 15–11–2—II–I:

15-11-2—II-I.	Plant	1	=	2.56	grams.
"	"	2	=	2.48	"
"	"	4	=	3.06	"
"	"	5	=	1.49	"
"	"	7	=	1.48	"
"	"	8	=	2.28	"
"	"	9	=	1.86	"
"	"	10	=	3.18	"
"	"	11	=	4.16	"
"	"	12	=	2.55	"

The average weight of fruit for the above series is 2.54 grams.

The series 15–11–2—II–II, was composed of F-2 plants which gave the following average weights of fruits:

15-11-2—II-II.	Plant	1	=	1.43	grams.
"	"	3	=	1.99	"
"	"	4	=	1.89	"
"	"	5	=	1.94	"
"	"	6	=	3.42	"
"	"	7	=	1.53	"
"	"	8	=	1.56	"
"	"	9	=	3.34	"
"	"	10	=	3.80	"
"	"	11	=	2.00	"
"	"	12	=	1.69	"
"	"	14	=	2.69	"
"	"	15	=	2.42	"
"	"	17	=	2.60	"
"	"	18	=	2.25	"
"	"	19	=	2.61	"
"	"	20	=	1.33	"
"	"	21	=	2.87	"

The average weight of fruit of this series is 2.29 grams.

The following table shows the average fruit-weights of plants of the F-2 series 15–11–2—5–1:

15-11-2—5-1.	Plant	1	=	3.39	grams.
"	"	2	=	2.36	"
"	"	3	=	3.30	"
"	"	4	=	2.11	"
"	"	6	=	2.67	"
"	"	7	=	2.86	"
"	"	8	=	3.83	"
"	"	9	=	1.36	"
"	"	10	=	2.36	"
"	"	11	=	1.87	"
"	"	12	=	1.88	"

The average weight of fruits of this series is 2.54 grams.

The fruits of the F-2 series 15–11–2 gave the following average weights of fruits:

15-11-2.	Plant	1	=	2.36	grams.
"	"	3	=	1.76	"
"	"	5	=	3.60	"
"	"	6	=	2.16	"
"	"	7	=	3.00	"

The average weight of fruits of this series is 2.58 grams.

These four series of F-2 generation hybrids give a total of 44 F-2 plants whose average fruit-weights vary from 1.33 grams to 4.16 grams. The lightest fruit possessed a weight of .38 gram while the heaviest fruit weighed 5.63 grams. The variability of the F-2 fruits was greater than that of the F-1 fruits. The average fruit-size of the F-2 generation plants agrees fairly well with the average of the fruit-size of the parent F-1 generation. Distinct segregation of size characters was noted in the F-2 fruits.

The following table shows the average fruit-weights of the plants of the F-3 generation (17–12–4):

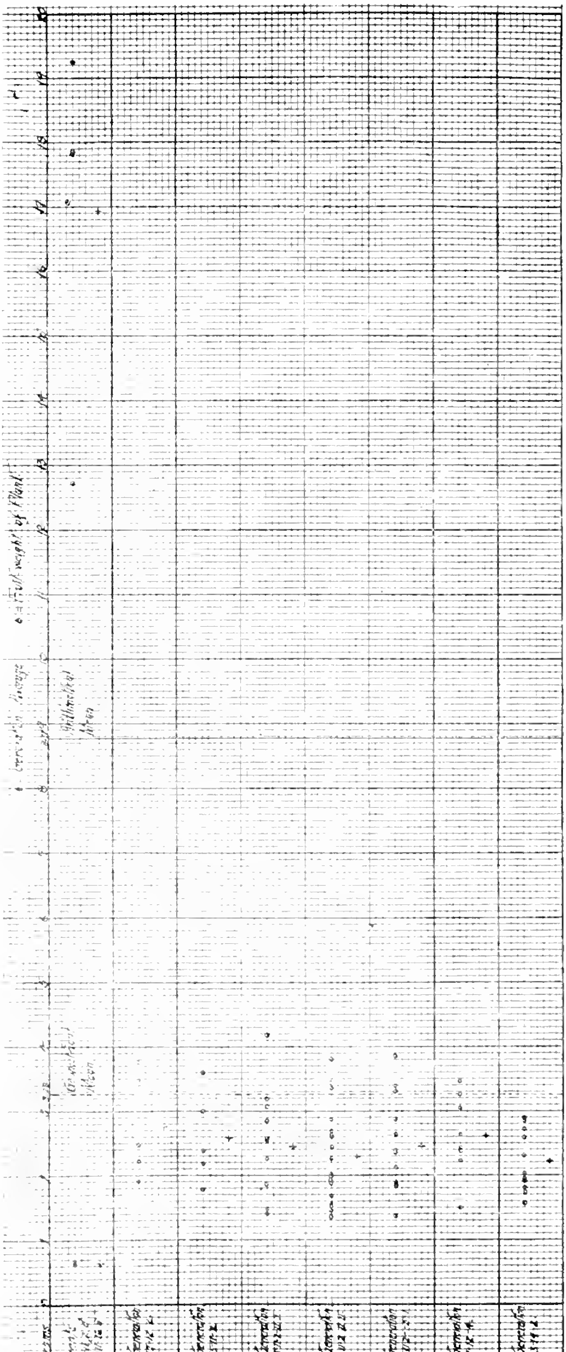
17-12-4.	Plant	1	=	3.25	grams.
"	"	4	=	2.40	"
"	"	5	=	2.42	"
"	"	6	=	3.06	"
"	"	7	=	1.50	"
"	"	8	=	3.46	"
"	"	9	=	2.62	"
"	"	10	=	2.22	"

In this generation segregation of size characters of fruit was observed. The average weight of fruit for this generation was found to be 2.62 grams. The variability and generation average are practically the same as in the F-2 fruits.

From plant 10 of the F-3 series came the seeds which produced the plants of the F-4 generation (43–14–2). This generation was grown in the garden. The average fruit weights of the different plants are as follows:

43-14-2.	Plant	1	=	2.30	grams.
"	"	2	=	2.73	"
"	"	3	=	1.94	"
"	"	4	=	1.95	"
"	"	5	=	1.80	"
"	"	6	=	1.74	"
"	"	7	=	2.87	"
"	"	8	=	1.56	"
"	"	9	=	2.03	"
"	"	10	=	2.59	"
"	"	11	=	2.85	"

Segregation of size characters of fruit occurred in this F-4 generation. Both variability and the average size of fruit of the generation are somewhat less than in the F-3 fruits.



PERRY on "The Inheritance of Size in Tomatoes."

The average weight of fruit the F-3 parent, plant 10, is 2.22 grams while the F-4 generation possessed an average fruit-weight of 2.215 grams—a remarkable similarity between weight of parent fruit and the average weight of fruit of offspring. It is further to be noted that six fruits are lighter and five fruits are heavier than 2.22 grams, so that there is as equal a variation as fruit-size as possible in the offspring on each side of this parental fruit-weight. This relation between parent and offspring is graphically shown on Plate XXII.

Over 700 fruits were harvested from 74 plants in this series of experiments. This data is summed up and the relationship between the parental and hybrid fruit-weights is shown on Plate XXII.

INTERPRETATION OF RESULTS.

When the results, which were obtained, are interpreted it should be clearly kept in mind that the recorded weights represent the average fruit-weight of a single plant and not the weight of a single fruit. In practically all of the known experiments along this line the individual fruit-weights have been used as a basis for study and these weights have been shown in the tables of results. There is no evidence to show, in a number of experiments, at least, that any special care was observed in the selection of fruits, which seemed to be taken at random from a hybrid generation or a pure line of plants. The fluctuation in size of fruit on each plant; the difference in the number of fruits produced on each plant; and the variation in the length of the fruit-bearing period render the results secured by such harvesting liable to considerable error. On the other hand, when an accurate record is kept of each fruit and the average fruit-weight of each plant, more accurate results (especially the generation average based on the fruit-weight of the plants) are bound to be obtained.

There are only a few recorded experiments which deal comprehensively with the subject of the inheritance of size of fruit in the F-1 generation. This scarcity of data, taken together with its complexity, render the correct analysis of this problem very difficult. Especially has there been a great deal of discussion among scientific men as to whether the F-1 fruit-sizes approach more nearly to the geometrical or to the arithmetical mean between the parent sizes.

Groth, basing his statement upon linear dimensions, reports that the size of the F-1 tomato fruits is the geometric means between the parents. In this view he is supported by Bruee who had previously obtained like results with tomatoes. The data presented in this paper also shows that the F-1 fruits of the tomato (currant-pear cross) are the geometric means between the parental sizes.

Emerson says (b), "A hurried examination of data, both published and unpublished, derived from my own studies of size in beans and maize, indicates that the F-1 sizes are nearer the average than the geometric means between the parent sizes." When all of the available data of Emerson is considered, a part of the F-1 sizes show a near approach to the geometric mean and a part to the average. He made a cross between the Black Mexican and Tom Thumb varieties of corn and obtained an F-1 hybrid whose weight was the exact geometric means between the parent weights. The breadth of the hybrid seeds, however, show a closer approach to the arithmetical than to the geometrical mean.

A very extensive series of experiments have been conducted at the New Jersey Experiment Station upon the quantitative inheritance of characters in peppers. Part of the F-1 sizes approach the arithmetical and part approach the geometrical mean between the parents.

From the data enumerated above and from the other available data, it appears that there has not as yet been a sufficient amount of work done to enable a definite statement to be made, as to whether the F-1 fruits approach more nearly the arithmetical than the geometrical mean between the parental sizes. Neither is it certain that all the F-1 fruit-sizes can be made to approach more nearly to one than to the other of these two means. The suggestion came to the mind of the writer of this paper that perhaps there was some correlation between the relative difference of parental fruit-sizes and the approach of the F-1 fruit-size to the geometrical or arithmetical means between these parents. Accordingly all available data upon F-1 size inheritance was studied. This examination seemed to indicate that when two varieties are crossed which differ greatly in fruit-size (the fruit-size of one parent being probably about two, three or more times the size of fruit of the other parent), the resulting F-1 fruit-size will be nearer to the geometrical than the arithmetical mean; but when two parents similar in fruit-size are crossed, the size of fruit of the F-1 offspring will approach more nearly to the arithmetical than the geometrical mean. There are some exceptions to this statement but as a general rule it was found to be true. This statement has been formulated not because it is well understood but because it may suggest principles of size inheritance which lie deeper than those now known and which, it is hoped, will be more fully known in the light of future investigations.

The inheritance of size of fruit in the F-2 generation has received even less study than the inheritance of size in the F-1 generation. Groth seems to have been the only one to attempt an explanation. He has worked out a theoretical hypothesis,

(b) See (20) page 57.

based on linear dimensions, to show complete segregation of size characters, varying in the Mendelian fashion from the larger to the smaller parent. He assumes a cross between two tomatoes with the linear dimensions 4x4x4 and 9x9x9 respectively, and gets an F-1 hybrid which is 6x6x6. He assumes factors for length, width, breadth and shape. Shape modifies the dimensional factors, while each of the three dimensional factors modifies the other two, from which it can be seen that this is a multiple factor hypothesis. If all the tomato fruits were perfect spheres, this explanation would be more tenable; but, as noted before, the extreme irregularity of shape causes any explanation, founded on linear dimensions, to be liable to considerable error.

The results presented in this paper, showing apparently such unusual dominance of the red currant size factors, cannot be interpreted by Groth's hypothesis. However, a Mendelian explanation has been worked out which agrees fairly well with the facts. This explanation is given in the following paragraph, as it seems to be the best possible interpretation of these results at the present time.

As noted before, Nilsson-Ehle in his work on tri-hybrid red wheat found in the second generation 63 grains of varying redness to one white wheat grain. From this he reasoned that the red grains possessed three independent color factors each of which was able to give the red color to the wheat. In the F-2 tomato generation 44 plants have been grown and the segregation of size characters has been so incomplete as to warrant the assumption of at least four size factors. The small size factors of the red currant seem to be incompletely dominant over the large size factors of the yellow pear, because, when an equal number of large and small size factors are present, as in the F-1 generation, the geometrical mean between the parents is realized. As the number of small size factors increases or decreases from the number present in the F-1 generation so will the weight of the resulting fruit vary more or less from the geometrical mean. This variation will not be large, as the small size factors, however few, are incompletely dominant over any number of large size factors. There should be occasional returns to both parent sizes, the frequency depending upon the number of factors concerned. If, with further experiments, no such original parental size is ever attained, there is evidently more than multiple factors involved.

SUMMARY.

1. A more accurate representation of the size of tomato fruits can be obtained from their weights than from their linear dimensions.

2. The size of fruit of the F-1 generation of the currant-pear cross is the geometrical mean between the parental sizes.

3. From an examination of all available data upon the inheritance of fruit-size in the F-1 generation, it appears that, when two varieties are crossed which differ widely in fruit-size (the size of fruit of one parent being probably about two, three or more times the size of fruit of the other parent), the F-1 fruit-size will be nearer to the geometrical than the arithmetical mean; but, when two parents similar in fruit-size are crossed, the size of fruits of the offspring will approach more nearly to the arithmetical than to the geometrical mean.

4. The average fruit-size of the F-2 generation does not exceed and is even slightly less than the average fruit-size of the F-1 generation. The segregation of size factors and the incomplete dominance of the small size factors of the red currant parent may be explained by the assumption of at least four size factors. If no parental sizes can be ever obtained, there may be more than multiple factors involved.

5. The fruits of the F-2 and F-3 generations agree fairly well with respect to variability and average generation size. The F-4 fruits show diminished variability and size.

6. This paper deals only with the inheritance of size in the currant-pear tomato cross. Conclusions as to how far the results obtained may be applied to the inheritance of size in crosses between other species and varieties must be left to the accumulation of further data.

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EXPLANATION OF PLATES.

Plate XXIII.

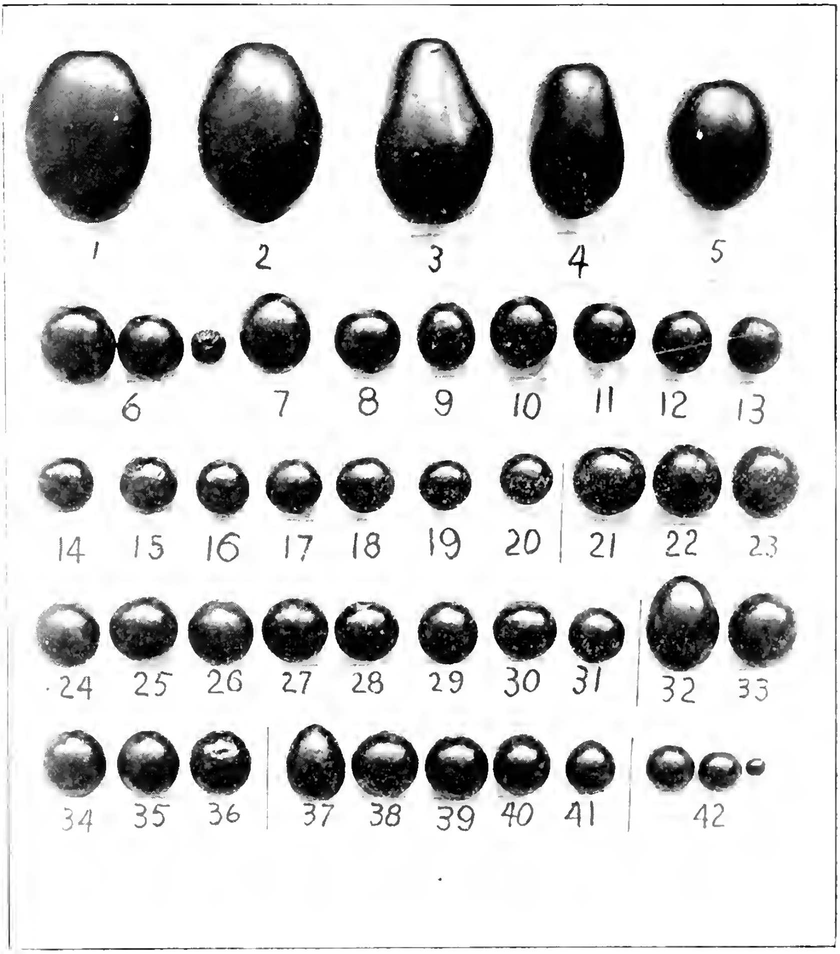
The different sizes of parent and hybrid fruits shown in this plate were photographed July 27, 1914, and the fruits were gathered and weighed two days before that date. It was not possible to show all of the different sizes and shapes of fruits as all the plants did not mature at the same time. One typical fruit was selected from each plant. In addition to the data given below the number of seeds of each fruit can be found in the records. The identity of the fruits is as follows:

NO. OF FRUITS.	FRUIT TAKEN FROM	WEIGHT IN GRAMS.	POLAR LENGTH MAX. DIAMETER, MIN. DIAMETER.	COLOR, SHAPE AND NO. OF LOCULES.
1	2-11-16. plant 3	21.04	41.5x32.5x28.7	yel., plum, 2
2	" " 5	20.02	43. x31. x29.	" " 2
3	" " 3	18.87	40.6x30.4x28.	" pear, 2
4	" " 5	13.13	37.2x25.1x24.1	" " 2
5	" " 4	12.69	32.1x26.8x24.4	" plum, 2
6	max. 17-12-4. plant 4	4.00	19.7x19.7x18.	red, sph. 2
6	av. " " 2	2.43	16.5x16.5x16.	" " 2
6	min. " " 2	.19	9.2x x	" " 2
7	15-11-2-II-II. plant 6	3.35	20. x18.1x16.8	" plum, 2
8	" " 19	2.45	16.2x17. x15.7	" sph. 2
9	" " 17	2.62	17.8x14. x14.	" egg, 2
10	" " 21	2.80	17.6x17.1x16.4	yel. sph. 2
11	" " 15	2.06	15. x15. x14.8	red, " 2
12	" " 4	2.29	15.9x11.9x11.3	" " 2
13	" " 3	1.91	15.1x14.1x13.8	" " 2
14	" " 7	1.79	14. x14.8x14.3	" " 2
15	" " 5	2.01	14.7x15.1x11.2	yel. " 2
16	" " 18	1.26	15.2x13.8x15.3	red, " 2
17	" " 14	1.61	14. x14.5x11.	yel. " 2
18	" " 1	1.76	13.9x15. x13.9	" " 2
19	" " 11	1.34	12.8x13.9x13.1	" " 2
20	" " 20	1.41	13.1x11.3x13.7	" " 2
21	15-11-2-II-I. " 10	3.37	17.2x18.2x17.7	" " 2
22	" " 2	3.22	18.7x17.6x16.6	red, " 2
23	" " 11	3.21	18.7x17.8x17.1	" " 2
24	" " 1	2.98	16.9x17.3x16.4	" " 2
25	" " 10	2.84	16.1x17.2x16.1	yel. " 2
26	" " 9	2.71	16.6x16.9x16.1	red, " 2
27	" " 8	2.68	16.4x16.9x16.	" " 2
28	" " 12	2.42	15.7x16.5x15.4	" " 2
29	" " 4	2.31	16.5x15.4x15.3	" " 2
30	" " 7	2.23	14.9x16.1x14.6	" " 2
31	" " 5	1.85	14. x14.6x13.2	" " 2
32	15-11-2. plant 5	1.51	24.5x18.9x18.1	" plum 2
33	" " 7	3.53	19. x18.7x17.7	yel. sph. 2
34	" " 1	2.72	17. x16.8x16.1	" " 2
35	" " 3	1.47	17.3x15.9x15.8	red, " 2
36	" " 6	2.33	16.8x15.9x15.4	" " 2
37	17-12-4. " 1	2.52	20.2x15.8x15.4	" egg, 2
38	" " 6	1.51	16.1x16.4x16.2	yel. sph. 2
39	" " 8	2.38	16.4x16.3x15.6	red, " 2
40	" " 10	1.90	15. x14.5x14.	" " 2
41	" " 7	1.22	14.3x13. x12.5	" " 2
42	max. 7-14-2. " 4	1.04	12. x12.7x12.	" " 2
42	av. " " 4	.73	11.2x11. x19.4	" " 2
42	min. " " 4	.10	5.2x5. 7x 5.5	" " 2

Plate XXIV.

These fruits, harvested on September 24, 1914, were photographed on the following day. Two fruits were taken from each plant. In addition to the data given below, the number of seeds of each fruit has been recorded. The identity of the fruits is as follows:

No. of Fruits.	Fruit Taken From	Weight in Grams.	Polar Length, Max. Diameter, Min. Diameter.	Color, Shape and No. of Locules.		
1	43-14-2, plant 2	2.96	21.4x15.5x15.3	yel.	egg,	2
2	" " 2	2.76	21. x15.8x15.	"	"	2
3	" " 2	2.70	20.7x15.9x15.5	"	egg-pear	3
4	" " 2	2.24	20.9x15. x14.2	"	pear	2
5	" " 2	3.02	21.9x16.6x15.3	"	egg	2
6	" " 7	3.08	18.3x17.5x16.2	red,	sph.	2
7	" " 7	3.39	19.1x18.2x16.3	"	"	2
8	" " 11	2.93	19.3x16.9x16.	"	plum	2
9	" " 11	2.93	20.1x16.8x15.9	"	"	2
10	" " 10	2.77	17.3x16.8x15.5	yel.	sph.	2
11	" " 10	2.66	15.9x17. x15.8	"	"	3
12	" " 9	2.33	15.6x15.6x15.	red	"	2
13	" " 9	2.23	15.5x15.3x14.7	"	"	2
14	" " 1	1.33	14.5x16.1x15.6	yel.	"	3
15	" " 1	2.31	x15.8x	"	"	3
16	" " 8	2.88	17.8x17. x16.7	red	"	3
17	" " 8	1.72	14.9x13.9x13.5	"	"	2
18	" " 4	2.21	15. x15.8x14.8	"	"	2
19	" " 4	1.95	14.5x15. x14.6	"	"	3
20	" " 3	2.23	15.7x x14.6	yel.	"	2
21	" " 3	2.13	15.6x15.5x14.7	"	"	2
22	" " 5	2.17	15.1x14.8x14.1	red	"	2
23	" " 5	1.44	x x	"	"	2
24	" " 6	1.77	14.8x14.2x13.6	"	"	2
25	" " 6	1.72	14.4x14.4x13.3	"	"	2



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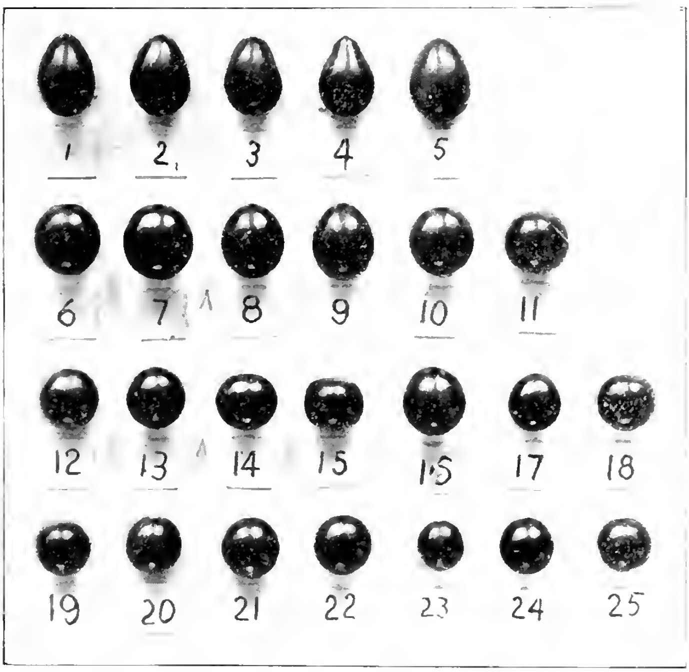

Perry on "Inheritance of Size in Tomatoes."

A LAND PLANARIAN WITH AN ABNORMAL NUMBER OF EYES.

L. B. WALTON.

The land planarians which are relatively common in the tropical regions have few representatives in the temperate zones, only two species thus far being known from America north of Mexico, with the exception of the introduced form, *Placocephalus kewense* (Moseley) occurring in the hot houses. These are *Rhynchodemus sylvaticus* (Leidy) and *Rhynchodemus atrocyaneus* Walton, the latter represented by only two specimens and the former by ten specimens all belonging to the collection of the Department of Biology, Kenyon College. It is therefore of interest to record a specimen belonging to the former species which possesses two

Fig 1. *Rhynchodemus sylvaticus* (Leidy). A Land Planarian from Ohio with an abnormal pair of eyes. A. Entire individual slightly contracted (x10). B. Head showing relative size of eyes (x25).

pairs of eyes instead of the normal single pair. The individual was among five collected July 4, 1904 under the partially decayed stem of a Virginia Creeper—*Ampelopsis quinquefolia*, and the peculiarity was not noted until sometime later when cleared in cedar oil preparatory to sectioning.

The two pairs of eyes are nearly normal in position, the anterior pair being 0.26 mm. and the posterior pair 0.33 mm. from the tip of the head in the preserved specimen fixed in hot sublimate alcohol (Apathy) and somewhat contracted. The anterior pair

is nearly twice the diameter of the others. No peculiarities of this nature have thus far been noted among land planarians although vonGraff ('99) in his monograph briefly discusses certain variations in other organs.

It is of interest to extend the range of our land planarians and those engaged in work in Invertebrate Zoology should be able to find them, particularly on summer mornings after a rain, under partially decayed boards on lawns, in orchards, etc., in company with young snails which they superficially resemble.

R. sylvaticus was collected by Leidy in 1851-58 and the material evidently lost. Since then the writer has taken it at Gambier and Urbana, O., and at Meadville, Pa. It is about 10 mm. long, grayish black with two darker longitudinal lines dorsally. *R. atrocyaneus* is about 20 mm. long when in a living condition, and uniformally dark blue in color. It has only been found in Gambier, O. When collected, specimens should be killed almost immediately with some hot "killing fluid" inasmuch as they die and disintegrate very quickly. They may however, be kept alive for several hours in a small clean vial provided there is also placed within a piece of a partially decayed leaf.

Gambier, O.

KEY TO THE SEEDS OF THE WILD AND CULTIVATED GENERA OF PEAS AND BEANS IN OHIO.

GERTRUDE BARTLETT.

1. With a prominent beak-like micropylar point; seeds angular. *Cicer.*
1. Not with a beak like point. 2.
2. Seeds lenticular, flat, biconvex, with a groove beyond the hilum. *Ervum.*
2. Seeds not true lens shaped. 3.
3. With a prominent curved white pith-like raphe between the micropyle and the hilum. *Dolichos.*
3. Not with a prominent pithy white raphe. 4.
4. Hilum broad at one end and tapering to a point at the other, surrounded by a groove of darker color; short, kidney-shaped, more or less angular or irregular. *Vigna.*
4. Hilum, regularly oval or linear. Not broad at one end and narrow at the other. 5.
5. Seeds truncate at both ends. 6.
5. Seeds not truncate at both ends. 7.
6. A narrow white line or ridge along almost the entire hilum; testa scurfy. *Strophostyles.*
6. Hilum of the same color as the seed; testa smooth. *Glycine.*
7. Two point-like or lip-like projections beyond the hilum separated by a groove. *Phaseolus.*
7. Not having point-like projections beyond the hilum. 8.
8. Spherical, or ellipsoidal, the sides not flattened. 9.
8. Flattened on the sides, rounded at the ends. 10.
9. Veining of the testa prominent unless dark colored, often more or less bean-shaped or elongated, usually more than $\frac{1}{4}$ in. long. *Soja.*
9. Veining not prominent, generally spherical. 11.
10. Hilum one-fifth of the circumference. *Vicia.*
10. Hilum much less than one-fifth of the circumference. *Falcata.*
11. Color white, yellow, green or gray; hilum the color of the testa; usually over $\frac{1}{4}$ in. in diameter. *Pisum.*
11. Brown to black; hilum having a conspicuous ridge, or indentation. *Vicia* and *Phaseolus.*

Date of Publication, April 17, 1915.

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ADDITIONS AND NOTES ON THE HEMIPTERA-HETEROPTERA OF OHIO.*

HERBERT OSBORN and CARL J. DRAKE.

Some years have passed since the last record of additions to the Hemipterous fauna of Ohio was made, and in the meantime a number of additional species have been noted. It seems desirable to place on record the occurence of these species at this time.

A number of these species were collected by the senior writer, but in recent years his attention has been directed particularly to the Homoptera. About two years ago, the junior author began a survey of the aquatic and semi-aquatic Heteroptera of the state and, incidentally, he has noted many other observations on Heteroptera which are embodied in this paper.

The papers† in which previous records were made have appeared in the Ohio Naturalist, except for the first contribution

*Contribution from the Department of Zoology and Entomology, Ohio State University. No. 39.

†Remarks on the Hemipterous Fauna of Ohio with a Preliminary Record of the Species (Proc. O. Acad. Sci. pp. 60-79, 1900).

A list of Hemiptera Collected in the Vicinity of Bellaire, Ohio. (Ohio Nat., Vol. I, pp. 11-12, 1900).

Note on Aradus ornatus Say. (Ohio Nat. Vol. IV, p. 22, 1903).

Aradidæ of Ohio. (Ohio Nat., Vol. IV, pp. 36-42, 1903).

New Species of Ohio Fulgoridæ. (Ibid. pp. 44-46, 1903).

A Further Contribution to the Hemipterous Fauna of Ohio. (Ohio Nat., Vol. IV, pp. 99-103, 1904).

Report of Progress on Study of the Hemiptera of Ohio and Descriptions of New Species. (Ohio Nat., Vol. V, pp. 273-276, 1905.)

and, therefore, are accessible to members of the Ohio Academy of Science.

It may be noted that the senior author has been responsible for many of the identifications; the observations on life histories are to be credited particularly to the junior author.

Family Notonectidæ.

Buenoa platycnemis Fieber.

Numerous specimens, taken at Columbus, Franklin Co., by the junior writer.

Notonecta insulata Kirby.

Several specimens, taken at Berea, Cuyahoga Co., by the junior writer.

Notonecta variabilis Fieber.

One specimen, taken at the Ohio State Fair grounds in Columbus by the junior writer.

Family Nepidæ.

Ranatra kirkaldyi Bueno.

One specimen, taken by Prof. Sanders at Columbus?

Family Saldidæ.

Salda coriacea Uhler.

One specimen, taken at Oxford, Butler Co., by Prof. W. H. Shideler.

Salda sp.

One specimen, taken at Cedar Point by the senior writer.

Family Reduviidæ.

Arilus cristatus Linnæus.

Numerous specimens; taken at Sugar Grove, Fairfield Co., by Prof. Barrows; at Oxford by Prof. Shideler; at Columbus by Mr. L. A. Gephart.

Apiomerus crassipes Fabricius.

One specimen, taken at West Union, Adams Co., by Mr. W. Harbage.

Sirthenea carinata Fabricius.

Two specimens, taken at Athens, Athens Co., by Mr. C. M. Ochs, and at Buckeye Lake, Licking Co., by Mr. F. Cowles.

Melanolestes abdominalis Her.-Schfr.

One specimen, taken by the junior writer at Columbus.

Family GERRIDÆ.

Gerris canaliculatus Say.

One macropterous specimen, taken by the junior writer, October 15, 1913, on the Olentangy River (Ohio State University Farm.)

Gerris conformis Uhler.

One specimen, taken at Ironton, Lawrence Co., by Mr. R. C. Osburn; numerous specimens, collected by the junior writer at Berea, Olmsted Falls, and Columbus. This is a lacustrine as well as a fluviatile species. In the localities cited, several nymphs and adults were taken at various times during the past summer on ponds, small lakes, and streams. During the winter, they hibernate as adults and begin to copulate in early spring. The ova are deposited on material just beneath the surface of the water. In an aquarium, they were laid on floating cork just beneath the surface film and fastened with a viscous substance which is waterproof. These eggs began hatching in eleven days and the first adults appeared thirty-four days later, several requiring a few days longer to complete their metamorphosis. There are probably several generations during the summer, as nymphs and adults were taken on these same bodies of water during the latter part of the season. All specimens reared and collected were macropterous.

Limnogonus hesione Kirkaldy.

This tropical species is a noteworthy addition to our fauna. It has been recorded from Florida and Darien, Panama by Kirkaldy (Entomologist, 1902, p. 137).

One macropterous ♂, taken during the past summer at Galion, Crawford Co., by Mr. G. K. Rule; immense numbers of apterous ♂ and ♀, collected by the junior writer at Buckeye Lake, and at Minerva Park north of Columbus during September and October 1913, also at the latter locality and at the Ohio State Fair Ground in Columbus during September and October 1914. At these various times, numerous specimens were found copulating. Last October, several ♂ and ♀ were placed in an aquarium; in a few days eggs were deposited on floating cork just beneath the surface of the water. The males died a few days after coition, and the females a few days after the ova were deposited. Many of the individuals remained almost constantly *in coitu* for several days. As the ova and no adults could be found in early spring, the winter is probably spent entirely in the egg stage, while, later on and during the latter part of the summer, immense numbers were found on these same bodies of water. The eggs are slightly enlarged at one end and about three times as long as wide. They vary in length from one to one and one-third of a millimeter, and are of a dirty greenish-yellow color which becomes somewhat darker with age.

As the nymph emerges, the chorion is split longitudinally, the rupture extending a little over one-half of its length to well over the larger end. About fifty days after hatching the adult stage is reached, five ecdyses having taken place. So far as our observations have gone, it seems to be distinctly a lacustrine species, and found almost entirely in the apterous form. They are very active little creatures and congregate in immense numbers near the shore in sheltered places. They are predaceous. Their food

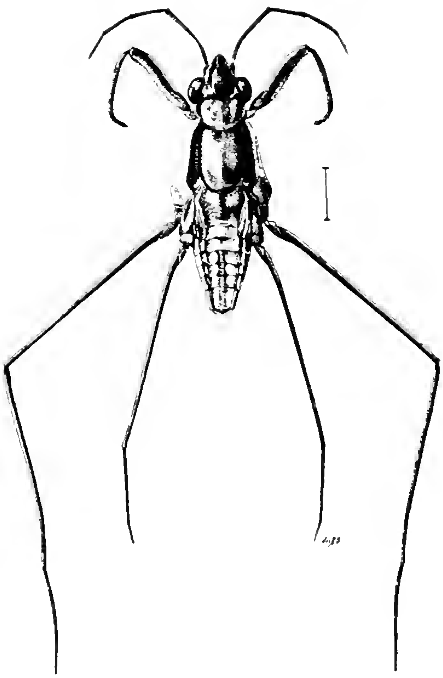


Fig. 1. ♀ Limnogonus hesione Kirk.
(From drawing by J. D. Smith.)

consists of small insects that fall into the water. In case there there are no living victims, they do not disdain food that has been dead for some time, and are often seen feeding on decaying insects. (Id. by Mr. J. R. de la Torre Bueno.)

Metrobates hesperius Uhler.

Immense numbers, taken at Berea, at Olmsted Falls, and at Columbus by the junior writer.

Mesovelia mulsanti F. B. White.

One nymph, taken at Sandusky by the senior writer.

Family Capsidæ.

Ceratocapsus pumila Uhler.
Taken at Cedar Point by the senior writer.

Resthenia insitiva Say.
One specimen, taken at Columbus by Mr. Vernon Haber.

Resthenia confraterna Uhler.
One speeimen, taken at Columbus by the junior writer.

Adelphocoris superbus Uhler.
Taken at Sandusky, Erie Co., and at Lakeside, Ottawa Co., by the senior writer.

Lygus vitticollis Reuter.
Two speeimens, taken at Sandusky by the senior writer.

Coquilletia mimetica Osborn.
Two speeimens, taken at Oxford by Prof. Shideler and at Columbus by the junior writer.

Paraxenetus guttulatus Uhler.
Several speeimens, taken at Cedar Point by Mr. DeLong.

Phytocoris tibialis Reuter.
Taken at Cedar Point by the senior writer.

Pœciloscytus americanus Reuter.
Two speeimens, eolleeted at Berea by the junior writer.

Pœcilocapsus marginatus Walker.
Numerous speeimens, taken at Oxford by Prof. Shideler; at Ironton, and at Vinton, Gallia Co. (Osburn and Hine); by the senior writer at Columbus and Sandusky,

Family Aradidæ.

Aradus quadrilineatus Walker.
Two speeimens, taken by Mr. R. J. Sim in Ashtabula Co., and by the senior writer at Columbus.

Aradus falleni Stal.
One speeimen, taken at Oxford by Prof. Shideler.

Aneurus inconstans Uhler.
Several speeimens, taken by Prof. Shideler at Oxford and in Ashtabula Co., by Mr. R. J. Sim.

Aneurus minutus Bergroth.
Taken at Cineinnati, Hamilton Co., by Mr. Chas. Dury.

Nannium pusio Heidemann.
This speeies was described by Mr. Heidemann in Ent. Soe. Wash., Vol. XI, p. 189 (Coll. Mr. Chas. Dury, Cineinnati, O.). The senior writer has two speeimens in his private eolleetion which were taken by Mr. Dury at Cincinnati.

Family TINGITIDÆ.

Corythuca marmorata Uhler.

Many specimens, taken at Castalia, Erie Co., by Mr. DeLong, while sweeping grasses and weeds near shrubbery.

Gargaphia tiliæ Walsh.

Several specimens, taken at Oxford by Prof. Shideler and at Cedar Point by Mr. W. J. Kostir.

Tingis clavata Stal.

♂ and ♀, collected at Castalia while sweeping grass by Mr. DeLong.

Family LYGÆIDÆ.

Lygæus bicrucis Say.

Several specimens, taken at Oxford by Prof. Shideler and at Columbus by Mr. H. D. Chase.

Heræus plebejus Stal.

One specimen, taken by the senior writer at Columbus.

Family CORREIDÆ.

Aufeius impressicollis Stal.

Large numbers, taken at Columbus by the junior writer while sweeping grasses on the University farm. This seems to be the first record of its occurrence east of the Mississippi river. In the private collection of the senior writer, there is a good series of specimens from Nebraska, South Dakota and Colorado.

This species varies in color and a little in size. Most of the specimens taken here are a little larger, and, as a rule, are of a darker color. There is a gradation in color and size until some of the specimens agree with the ones from the other localities while all agree in structure.

Anasa armigera Say.

Many specimens, taken at Columbus by Mr. Haber; at Sugar Grove by Prof. Sanders; at Chillicothe, Ross Co., by Mr. E. G. Heinzelman; and at Greenville, Darke Co., by Mr. Griff Eidson.

Catorhintha mendica Stal.

Two specimens, taken at Columbus and at Cedar Point by the junior writer.

Leptocoris trivittatus Say.

The season of 1913 witnessed a rather widespread occurrence of the box elder bug in the western part of the state, and, altho this is the first appearance of the species in the state, it seems to deserve a definite record and the attention of entomologists in adjoining states. The species is known to have migrated eastward thru Kansas, Iowa, and Illinois but, so far as we are aware no records for the species have been made for Indiana or Ohio' Within the last few years the species has evidently gained con-

siderable extension; its occurrence during the summer cited included localities all the way from the northern to the southern portion of the state and eastward to far past the central portion.

The localities indicated on the map will show the distribution of the species in the state. Many of these records were secured thru the Ohio Experiment Station, the Extension Department of Ohio State University, and members of the Department of Zoology and Entomology of the University. Thru these sources specimens have been received and identified from the following localities:

Fig. 2. Map showing distribution of Box Elder Bug in Ohio, 1913.

Oxford, Butler Co.; Williamsburg, Clermont Co.; Washington C. H., Fayette Co.; Osborn and Yellow Springs, Greene Co.; Catawba, Clark Co.; Ft. Recovery and Celina, Mercer Co.; West Liberty, Logan Co.; Columbus, Franklin Co.; Galena, Delaware Co.; Montpelier, Williams Co.; Liberty Center, Henry Co.; Bowling Green and Longley, Wood Co.; Helena and Clyde, Sandusky Co.; Chicago Jc. and Norwalk, Huron Co.; Berea, Cuyahoga Co.; Carrolton, Carroll Co.

The factors affecting the distribution within the state are not apparent, at least so far as the present records indicate. The advance within the state appears to be independent of all railway lines; this also seems substantially true of many of the different

river valleys and other topographic features. If only the northern series of records were taken into consideration, it might be thought to follow the principal railway lines of this portion of the state, but, moreover, several important railways pass thru counties that are not included among these records. It seems that the advance and dissemination of the species is due mainly to natural flight and its progress eastward may be expected to follow this method. It will be interesting to watch for the eastward extension of its present margin of distribution. During the summer of 1914, no records for the species were made in the state; if the insect is present during the coming summer, we will be glad to receive such records.

Family PENTATOMIDÆ.

Banasa packardi Stal.

One specimen, taken at Buckeye Lake by Mr. Cowles.

Apeteticus modestus Dallas.

One specimen, taken at Hanging Rock, Lawrence Co., by Prof. Hine.

Cœnus delius Say.

Many specimens of this widely distributed species have been collected: at Oxford by Prof. Shideler; at Medina, Medina Co., and at Blendon, Franklin Co., by Prof. Hine; at Tiffin, at Berea, and at Columbus numerous specimens were taken by the junior writer.

Euschistus servus Say.

Two specimens, taken at Oxford by Prof. Shideler, and at Sugar Grove, Fairfield Co., by Mr. Marshall.

Euschistus ictericus Linn.

Taken at Cedar Point by the senior writer, at Medina by Prof. Hine, and at Columbus by the junior writer.

Elasmucha lateralis Say.

Two specimens, taken at Rockbridge, Hocking Co. by Prof. Barrows and at Columbus by Mr. Axtell.

Dendrocoris humeralis Uhler.

Taken at Hanging Rock by Prof. Hine and at Columbus by the senior writer.

Neottiglossa undata Say.

One specimen, taken at Columbus by the senior writer.

Perillus bioculatus Fabricius.

Numerous specimens, taken by the junior writer at Berea, at Tiffin, and at Columbus. At Tiffin many specimens were found feeding upon the adult Colorado potato beetle.

Solubea pugnax Fabricius.

This is a southern species, taken at Hanging Rock, Lawrence Co. by Prof. Hine and at Columbus by Prof. Barrows.

THE CHROMOSOME MECHANISM AS A BASIS FOR MENDELIAN PHENOMENA.[1]

John H. Schaffner.

The farther investigation proceeds, the more convincing becomes the conviction that the proportional inheritance of characters of plants and animals has its basis in the chromatin of the nucleus. The remarkable parallelism between the activities of the complicated mechanism of nuclear division and the readily predicted phenomena of Mendelian inheritance easily dispels the allurements of any other hypothesis.

When in 1897[2] the writer showed the qualitative division of the reduction or bivalent chromosomes in the megasporocyte of Lilium philadelphicum, it was even then clearly seen by a number of cytologists that such a division would have an important bearing on heredity. At the time, however, there was no way of determining in the cells of the lily studied whether the separating transverse halves of the long, twisted loops were actually individual descendants of previous univalents, and Mendelian principles and laws were still resting in the limbo of neglected scientific discoveries. The theory of qualitative division was not kindly received at the time altho the investigation on Lilium philadelphicum showed not a single important break in the series until the complete segregation of the metakinesis stage. The weight of authority both in cytology and genetics was against such an explanation. My paper was begun with the following words:— "Altho a knowledge of the changes which take place in the reduction nuclei of plants and animals is of the utmost importance, and will not doubt aid more than anything else in bringing about a correct interpretation of the facts of heredity, comparatively little has been done in this field, and the observations that have been reported disagree widely."

In 1899, Paulmier[3] reported a transverse or qualitative division for the first reduction karyokinesis while the second was represented to be equational. These results on Anasa tristis agreed with what I had observed in Lilium philadelphicum. It was one of a very few thoro investigations of the times unbiased by contrary current opinion on the subject. In June 1901, the writer published his paper on Erythronium in which a qualitative

1. Contribution from the Botanical Laboratory of the Ohio State University, No. 88.

2. Schaffner, John H. The Division of the Macrospore Nucleus. Bot. Gaz. 23: 430-452.

3. Paulmier, F. C. The Spermatogenesis of Anasa tristis. Jour. of Morph. 15: 223-272.

Schaffner, J. H. A Contribution to the Life History and Cytology of of Erythronium. Bot. Gaz. 31: 369-387.

division in the first reduction karyokinesis was again reported essentially similar to that described for Lilium philadelphicum. At the time this paper was written, the writer still knew nothing of Mendelian heredity. The following statement was made in regard to the probable individuality of univalent chromosomes in the bivalent chromosome—"Altho there is no way known to the writer of tracing the origin of the reduction chromosome in this nucleus to two previous ones, theoretically one might consider it possible that the reduction chromosome represents two normal chromosomes, and the closed loop the point where the usual transverse break should have taken place." Namely, when the double number of chromosomes are formed from the continuous spirem. "But such a process would necessarily result in a qualitative division."

That the bivalent chromosome is actually made up of a pair of univalents, one from the maternal and one from the paternal side, was definitely shown to be the case by Montgomery[4] in 1904. Thus the general facts of the reduction division had been worked out and there was only needed a comparison of the results with the rediscovered Mendelian heredity. Such comparisons were of course, made by many writers.

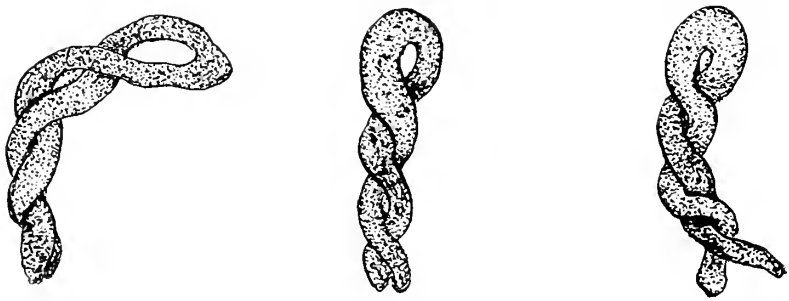
The cytological evidence may be summarized as follows: the chromosomes are self-perpetuating bodies which have a definite individuality of size and shape which can be recognized in many species. This individuality is not lost or impaired when the chromosomes spread out in the form of a network in the resting nucleus nor when they join end to end to form a continuous spirem. The haploid number of chromosomes represents a normal complement or set, each of which developes a specific attraction and unites with its corresponding or synaptic mate in the prophases of the reduction division (synapsis period) and each pair is segregated according to the law of chance to the two poles of the spindle. When at a future period gametes are formed and fertilization takes place, the univalents do not fuse but retain their separate existence during the entire zygotic stage of the organism. The pairing of corresponding univalents is of fundamental importance; for without such a process hereditary ratios would be much more complicated than what they really are, even tho the reduction division proceeded normally. The chromosomes representing synaptic mates may have absolutely similar hereditary factors and thus be homozygous and the

4. Montgomery, Jr. T. H. Some Observations and Considerations upon the Maturation Phenomena of the Germ Cells. Biol. Bull. 6: 137-158.

See also Montgomery: The Spermatogenesis of Peripatus (Peripatopsis) balfouri up to the Formation of the Spermatid. Zoolog. Jahrb. 14: 1900 and Montgomery; Mitosis in Amphibia and its General Significance. Biol. Bull. 4: 259-269, 1902.

race pure in respect to all hereditary phenomena resulting from the activity of the pair, or the pair may be heterozygous in which case Mendelian phenomena must result.

Now it will be apparent that with a definite number of chromosomes whose activities during the life cycle are known it can be determined before hand just what segregations and combinations of hereditary factors are possible. If the chromosomes are the only bearers of heredity, there should not be more Mendelian segregations of two absolute, heterozygous hybrids than the permutations possible with the number of chromosomes. By an absolute, heterozygous hybrid is meant one in which all the univalent chromosomes have at least one distinctive factor. So



a b c

Fig. 1, a, b, c. Bivalent or reduction chromosomes from a megasporocyte of Lilium philadelphicum. The two longitudinal limbs of the twisted loop represent two univalent chromosomes, one maternal and one paternal, fused end to end in synapsis and folded lengthwise, the synaptic joint being at the head of the loop. Each univalent has already divided longitudinally into two daughter chromosomes but these are not evident in the figures which were taken from a preparation stained with a rather diffuse stain. It was this type of chromosome which first lead the writer to the conclusion that the reduction division is a qualitative division. The true nature of the formation and division of these chromosomes can only be determined by studying the preceding and subsequent stages.

far as the writer knows, the possible segregations of distinct combinations have never been tested practically. In Canna (as will appear below) which is said to have but six univalent and three bivalent chromosomes, there would be twenty-seven possible varieties from two original pure lines without considering possible new characters which might appear as the result of the activity of a heterozygous pair. This is perhaps the best plant on which the theoretical expectation might be tested out. Unfortunately many of the varities produce little or no seed. The hybridization would have to be carried on between varieties giving completely fertile offspring.

Now we can make the following possible hypotheses in regard to heredity:

1. All the hereditary factors are in the cytoplasm and other protoplasmic structures outside of the chromosomes.
2. Part of the hereditary factors are in the chromosomes and part in the protoplasm outside of the chromosomes, especially in centrosomes and plastids.
3. All the hereditary factors are resident in the chromosomes.

The last hypothesis still seems to explain all known hereditary phenomena. It is probable, however, that all protoplasmic structures have hereditary factors. Nevertheless, we can safely say that all normal Mendelian heredity must have its factors in the chromosomes alone.

Now it may easily be true that certain hereditary factors may be resident in all of the chromosomes of a haploid set, and if the synaptic haploids also contained the factor, it could not be segregated out in reduction. Fundamental characters may be of this nature. A loss of part of the nucleus would not result in a loss of essential factors. The factor may be in all but one of the haploid set, all but two, etc., and finally in but one chromosome. We can conceive that new trivial or superficial factors commonly originate in but one chromosome or in one synaptic pair and that later the property might be acquired by other chromosomes of the set. If only one chromosome contains the factor, the simplest kind of Mendelian phenomena will result, in breeding distinct varities.

It is self evident that each chromosome and probably each of its component organs contains many hereditary abilities or factors. If two definite factors, each of which can produce a distinct character, are in the same chromosome, the factors and characters must be always linked until the chromosome breaks up abnormally into new units or individuals. Such, apparently chromosome-linked factors are well known.

Fundamentally, entirely independent of chromosome synapsis and segregation are the phenomena of dominance and recessiveness. These show a similarity to activity and latency of factors as observed in the ordinary growth and life cycle. These phenomena have nothing to do with our chromosome hypothesis except in so far as dominant and recessive factors may be shifted from one heredity set or combination to another. Dominance and recessiveness should come under possible control like latency and activity. Dominance and recessiveness when compared to activity and latency of factors do not decidedly indicate presence and absence. From the standpoint of the chromosome hypothesis a recessive factor may be either an absence or a presence. The whole problem of the influences which cause, modify, or prevent

the expression of a character from a specific factor is one which presents a marvelous field for investigation and experimentation. The influence of the ordinary ecological factors has been studied to some extent but not from the exact standpoint of the systematist and geneticist. One need only consider the remarkable structures developed in certain insect galls to be impressed with the fact, that specific characters can be developed without any previous phylogeny of the character in relation to the factor being involved. It is evident that the same factors may give rise to very diverse types of characters, when their immediate environment is changed. The influence of the sexual condition and one factor or set of factors on another may come under the same general category of environmental influences determining expression.

On the hypothesis that the chromosomes contain the hereditary factors, the possible number of gametes and zygote combinations, giving rise to diploid individuals is given below. These results must necessarily follow according to the law of chance so long as the chromosomes retain their individuality, pair as synaptic mates in reduction, and segregate and combine according to the law of probablity.

Let x = number of chromosomes.

If x = 1 and 2x = 2;

And chromosomes a ♦ — ♦ n

Then gametes {eggs or sperms} = a n

Possible combinations = 4.

aa an na nn

Hereditary constitutions = 3

a_2 an n_2

If x = 2 and 2x = 4

Chromosomes a ♦ — ♦ n
b • — • o

Gametes {eggs or sperms} = $\begin{matrix} a & a & n & n \\ b & o & b & o \end{matrix}$

Possible combinations = 16, as follows:

abab	aoab	nbab	noab
abao	aoao	nbao	noao
abnb	aonb	nbnb	nonb
abno	aono	nbno	nono

Cancel similar constitutions and there are 9 combinations as follows:

a_2b_2	$anbo$	n_2b_2
a_2bo	a_2o_2	n_2bo
anb_2	ano_2	n_2o_2

If x = 3 and 2x = 6;

Chromosomes a ♦ — ♦ n
b ⬤ — ⬤ o
c ▼ — ▼ p

The following types of gametes are possible, either male or female:

a	a	a	n	a	n	n	n
b	b	o	b	o	b	o	o
c	p	c	c	p	p	c	p

Possible combinations = 64

Cancel similar ones and there are left 27 types of chromosome constitutions.

$a_2b_2c_2$	ano_2c_2
a_2b_2cp	ano_2cp
a_2boc_2	$n_2b_2c_2$
anb_2c_2	n_2b_2cp
a_2bocp	n_2boc_2
anb_2cp	n_2bocp
$anboc_2$	$a_2o_2p_2$
$anbocp$	ano_2p_2
$a_2b_2p_2$	$n_2b_2p_2$
a_2bop_2	n_2bop_2
anb_2p_2	$n_2o_2c_2$
$anbop_2$	n_2o_2cp
$a_2o_2c_2$	$n_2o_2p_2$
a_2o_2cp	

If x = 4 and 2x = 8;

Chromosomes a ♦ — ♦ n
b ⬤ — ⬤ o
c ▼ — ▼ p
d ● — ● q

The following gametes are possible.

a	a	a	a	n	a	a	a	n	n	n	a	n	n	n	n
b	b	b	o	b	b	o	o	b	b	o	o	b	o	o	o
c	c	p	c	c	p	p	c	p	c	c	p	p	c	p	p
d	q	d	d	d	q	d	q	d	q	d	q	q	q	d	q

In this case 256 types of matings are possible giving rise to 81 varieties of hereditary constitutions.

If x = 5 and 2x = 10;

Chromosomes
a ♦ — ♦ n
b ● — ● o
c ▼ — ▼ p
d ● — ● q
e ■ — ■ r

The following gametes are possible:

a	a	a	a	a	n	a	a	a	n	a	a	n	a	n	n
b	b	b	b	o	b	b	b	o	o	b	o	b	o	b	b
c	c	c	p	c	c	c	p	p	c	p	c	p	c	c	c
d	d	q	d	d	d	q	q	d	d	d	q	d	d	q	d
e	r	e	e	e	e	r	e	e	e	r	e	e	r	e	r

a	a	n	a	n	n	a	n	n	n	a	n	n	n	n	n
o	o	b	o	b	o	b	b	o	o	o	b	o	o	o	o
p	p	p	c	p	c	p	c	c	p	p	p	c	p	p	p
q	d	q	q	d	q	q	q	d	d	q	q	q	d	q	q
e	r	e	r	r	e	r	r	r	e	r	r	r	r	e	r

From these 1024 combinations are possible, representing 243 constitutions.

If x = 6 and 2x = 12;
64 kinds of male or female gametes possible,
4,096 chance combinations,
representing 729 hereditary constitutions.

If x = 7 and 2x = 14;
128 kinds of gametes possible,
16,384 combinations,
representing 2187 constitutions.

If x = 8 and 2x = 16;
256 kinds of gametes,
65,536 combinations,
representing 6561 constitutions.

If x = 9 and 2x = 18;
512 kinds of gametes possible,
262,144 combinations,
representing 19,583 constitutions.

If x = 10 and 2x = 20;
1,024 kinds of gametes possible,
1,048,576 combinations,
representing 58,749 constitutions.

If x = 11 and 2x = 22;
: 2,048 kinds of gametes possible,
: 4,194,304 combinations,
: representing 176,247 constitutions.

If x = 12 and 2x = 24;
: 4,096 kinds of male or female gametes possible,
: 16,777,216 combinations,
: representing 528,741 actual constitutions, or over half a million.

The presence of an allosome, which may contain hereditary factors, complicates the results of Mendelian segregation and probably is the cause, at least in many cases, of sex-limited characters. That the factors are not to be regarded as sex-linked becomes obvious in such a case as color-blindness in man. For there are both color-blind men and women, but thru the reduction mechanism by which the allosomes are segregated and the new combinations brought about during fertilization, thru the influence of the sex determination of the egg, it happens that many more males show the color blind character than females. If we assume differential attraction between eggs and sperms and if there is an accessory chromosome or allosome in man and if the factor for color-blindness is associated with this chromosome, then it would follow that a color blind man mated with a normal woman could have no color-blind children because the two types of eggs would be normal and the egg determined as female would attract the sperms containing the allosome (i. e. having the color-blind factor) and this would give but a single dose which is not sufficient to produce the color-blind character in the female. The egg determined with male condition would attract only sperms without the allosome; therefore, all the males would be normal, but the color-blind female having a double dose would produce eggs, all of which, whether determined as male or female, would have the color-blind factor in the allosome, and if mated with normal, the sons would all be color-blind, because a single dose produces the color-blind character under the influence of the male condition. The daughters would be normal having only a single dose, which as stated. is not sufficient to develop the color-blind character in the presence of the female condition in the cells of the body. These suppositions agree with the observed facts. It also comes about that in hybridizing individuals, which may have a specific factor in the allosome, different degrees of the character may be shown because a double dose may give a greater degree of the character than a single dose. If the male

has one allosome and the female two, the highest efficiency character may appear to be transmitted only thru the male simply because the female cannot get the double dose of favorable allosomes except from a male. It is probable also that there are sex-limited characters whose factors are not in the allosome. In such cases the male of female condition modifies the activity of the factor.

Besides the segregating results due to normal cell divisions there is, of course, the possibility of irregular segregations and the fusion of parts of one chromosome with another. Irregularities in reduction and vegetative karyokineses may thus produce fundamental changes in heredity. Irregularities may be of three general types.

a. The chromosomes may be doubled from the previous number of the species, probably thru failure of a reduction division.

b. Increase or decrease of the usual number may be brought about by some of the chromosomes being left behind on the spindle, or by the entire synaptic pair or the daughter halves being pulled to one pole.

c. Material from one chromosome may possibly be transferred to another when fused ends of two univalents are pulled apart in the reduction metakinesis and material belonging to one chromosome might also be detached and drawn into another during the protochromosome stage of reduction.

The question of the origin of an hereditary factor in a chromosome or the absolute loss of a factor involves a consideration of the mechanism, and the chemical, physical and vital properties of the chromosomes about which we know little or nothing at the present time. But that the chromosome itself is a mechanism apparently as complex in its own way as the nucleus itself is revealed by the microscope even with present methods. What further complications may exist until the larger chemical units are reached can only be conjectured. There is also a possibility that the mosaic arrangement of the chromosomes in the zygote may influence the expression of hereditary factors and the arrangement and adjustment of chromatin granules and any other structures present in the linin plasm may have something to do with the peculiar hereditary properties or abilities manifested by living matter.

SUMMARY.

The normal hereditary mechanism then of the chromosomes acts as follows:

1. The chromosomes normally function as individuals and are segregated as such at each karyokinesis.

2. The chromosomes do not conjugate or fuse, nor does their material mix in the fertilization stage; but each chromosome is carried thru the zygote stage of the organism as a definite individual.

3. In the reduction division, the chromosomes show themselves to be definitely paired; and the 2x number of the zygotic individual represents two definite sets or complements of chromosomes, each one of the one set having its corresponding synaptic mate in the other. A specific attraction develops between each pair of synaptic mates during the prophases of reduction resulting in an end to end fusion in pairs and a subsequent folding side by side, so that a bivalent chromosome represents synaptic univalents fused longitudinally at least in the ordinary elongated types of chromosomes.

4. The segregation of the univalents during reduction is according to the law of chance; therefore, each daughter cell receives a full (x) complement of univalents, some of the set being descendants of those brought into the zygote by the parent egg and some by the sperm.

5. These processes are in harmony with the observed phenomena of Mendelian heredity.

CORRECTION

The list of Insect Galls of Cedar Point (Ohio Naturalist, December, 1914) is in error as follows:

P. 381—**Andricus futilis** O. S. should doubtless be **Dryophanta papula** Bassett.

P. 382—**Holcaspis globulus** Fitch was found on **Quercus macrocarpa** instead of **Q. imbricaria.**

I am indebted to Mr. L. H. Weld of Evanston, Ill., for these corrections.

PAUL B. SEARS.

BURIED STREAM CHANNELS AT THE BASE OF THE PENNSYLVANIAN SYSTEM IN SOUTHEASTERN OHIO.[1]

C. R. Schroyer.

Contents:

Numerous and marked irregularities are present at the top of the Mississippian strata in Ohio. Professor C. F. Lamb finds the surface a series of north-south ridges with alternating depressions in northeastern Ohio.[2] Dr. J. J. Stevenson, collecting the scattered evidence for a wider area has interpreted this surface as the effect of a wide spread subærial erosion.[3]

It seems worth while to add some observations made in southeastern Ohio. Over wide areas the contact is very regular; so much so that, were it not for the general difference of the strata above from that below, it might be taken for a bedding plane. Minor irregularities do occur but only by careful search and comparison of elevations can evidence be found of a time break as long as this one appears to have been.

THE CONTACT A LEVEL PLANE AT THE NORTH.

The contact between these two systems is almost a level plane from Newark to Logan, crossing Licking, Perry, and Fairfield Counties. The regularity may be inferred from the fact that in an east-west section of twenty-two miles extending west from White Cottage past Mt. Perry, the base of the Pennsylvanian strata lowers 420 feet to the east and in the twenty-two exposures studied not a single one shows a counter dip. Another section along the National Road from Amsterdam on the west to Gratiot at the east shows a regular eastward inclination of about 19 feet to the mile. If this be extended eastward to where the Waverly goes under in the Licking River at Dillon, it gives a relief of 400 feet in 18½ miles or 21.6 feet to the mile. This inclination approaches the reported dip of the bed rock.

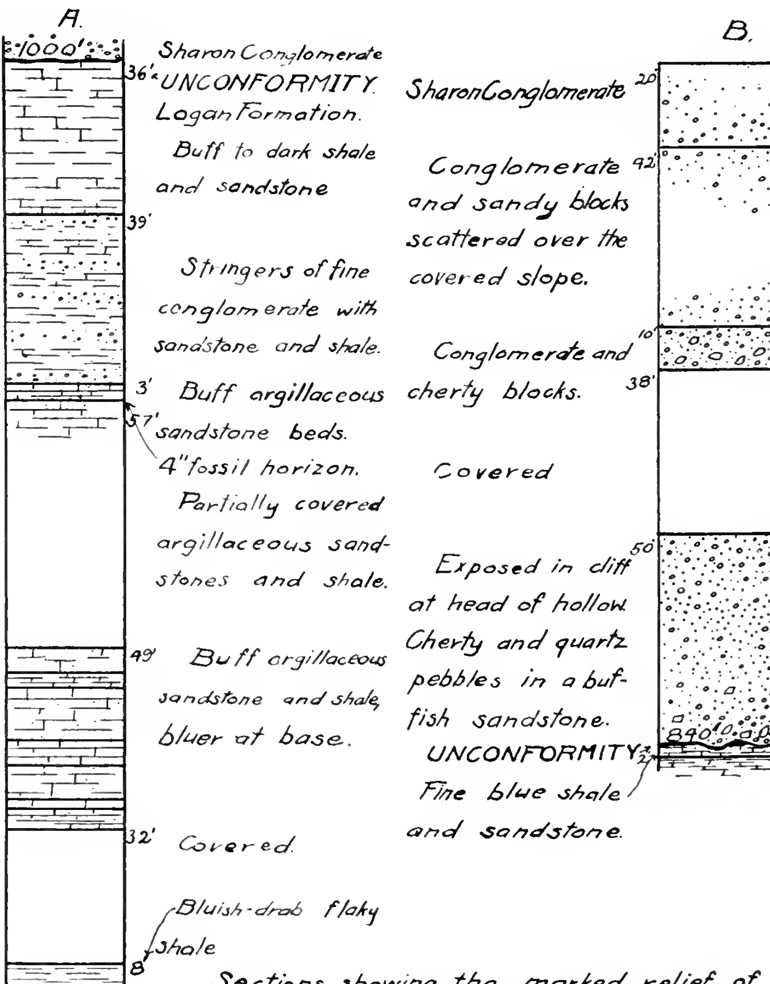
1. Published by permission of the Director of the Ohio Geological Survey.

Partial abstract of the material offered as a Master's thesis at Ohio State University.

2. Jour. of Geol., Vol. 19, p. 104, 1911.

3. Bull. Geol. Soc. of America. Papers in Vol's. 14, 15, 17, and 18.

A.—SECTION AT HEAD OF BIG RUN
B.—SECTION IN HAY HOLLOW ONE MILE NORTH.



Sections showing the marked relief of the erosion plane and the subsequent filling of Sharon Conglomerate.

THE CHANNEL SOUTH OF LOGAN.

South of Logan the regularity is broken by the scar of a buried channel. It extends in an east and southeast direction across the south central part of Falls Township, Hocking County and can be first distinctly seen along a west tributary to Dry Run. After meeting that stream farther east it turns south past the junction with Scott Creek finally burying itself under a continuous blanket of Pennsylvanian rocks one mile north of the village of Ewing. This channel is clearly marked by the filling—a coarse quartz sandstone usually stained a reddish brown by the weathering of the iron cement. Occasional well-rounded quartz pebbles may be found. The depression extends as a distinct channel for a distance of four miles, its width changing from place to place, due both to variations in the original channel and the depth to which the filling has been removed by recent erosion. At one place it is 400 yards; where Scott Creek has cut well down into the filling it is but little over 150 yards wide.

The exact depth was not obtained but from the general level of the basal sandstone beyond the borders of the channel to the lowest exposed rock of the same character is a vertical distance of over 100 feet. At the north a small tributary to Dry Run has cut down to the Waverly almost half way across the channel. Judging from this the bottom is not far below. The elevation is near 779 feet above sea level, while the lowest exposure to the south is below 755 feet, indicating a southward gradient. Just above the junction of Dry Run with Scott Creek buff colored Waverly shales were found in grave diggings; across the road to the west coarse iron-stained sandstone forms the bed of the present stream, giving a relief of 55 feet in little over twice that distance horizontally.

The abrupt curve in its course, the depth of the depression and the steepness of the slopes at the sides are strong evidences of the action of meteoric waters.

THE CHANNEL SOUTH OF BYER.

Another buried valley may be found one mile south of Byer, the station at the junction of the Baltimore and Ohio Southwestern and the Cincinnati, Hamilton and Dayton Railroads. It crosses the present valley of Pigeon Creek where that stream receives the second tributary from the west. The direction is a little south of west or north of east but only along the sides of this valley is the depression distinctly visible. In these outcrops it is a cross-bedded quartz conglomerate enclosed on each side by drab to gray argillaceous shales and sandstones. Surface weathering has worn away the less resistent material thus exposing the coarse conlomerate filling on the east bank of Pigeon Creek. There, in

a small ravine, a wall of conglomerate may be found opposite slopes covered by weathered Waverly. At the head of the ravine the highest Waverly is almost 100 feet above the level of Pigeon Creek where the conglomerate forms the bed of that stream. Across from this ravine layer after layer of horizontal argillaceous shales and sandstones end abruptly against the filling of cross-bedded conglomerate and sandstone. Usually the outer edges of the beds show a slight slumping or bowing downward as if the overlying filling had compressed them after they had been exposed to erosion. The south boundary is less definitely marked but the width is about 200 yards. But a very thin coating and in many places no trace of pebbles may be found outside this channel.

EVIDENCES POINTING TO A CONTINUOUS STREAM SYSTEM.

Such sections seem to imply that the pebbles of the conglomerate were borne largely by strong surging currents restricted within the channels themselves. These currents would most likely be found in a continuous system of channels and although hidden in many places by the overlying Pennsylvanian strata, traces of such a system can be found. At Richland Furnace two miles northeast of the conglomerate outcrops last mentioned the coarse sandstone and basal conglomerate lowers from 812 feet above sea level on the west and 762 on the east to below the 700 feet contour. Pebbly beds may be found below the Baltimore and Ohio Southwestern Railroad at that place, while on either side they rise to the heights mentioned.

West and south traces of this line of conglomerate filling are exposed along Glade Run, and at Canter's Cave three and a half miles soutwest it forms vertical cliffs from which large caverns have been worn by weathering. Such conglomerate walls continue south to Jackson where they form the well-known Jackson Conglomerate area. The conglomerate there becomes more general but its thickness still varies.

Tributaries join this system from the west. A definite and well marked line of conglomerate ledges extends northwest for a distance of over seven miles. The present elevation of the bed of this channel above sea level is as follows:

890 feet at the exposure south of Hay Hollow
840 feet at the head of Hay Hollow
807 feet in the first large hollow west of Big Rock
742 feet at the base of Big Rock
690 feet at the head of Pigeon Creek where the base of the conglomerate goes under.

In all, this gives a relief of 200 feet in less than 6 miles. After allowing for the gentle southeast dip of about 25 feet to the mile a gradient of 30 to 50 feet still remains. This conglomerate is

bounded on the north by a ridge of Waverly which rises as much as 100 feet above the bed of the channel. On the south at Linn Post Office the contact is at an elevation of about 1000 feet above sea level; at the Pike-Jackson County boundary line, 900 feet on the north and 950 feet on the south. The structure sections show the relation and comparative elevation of the contact at Linn and in Hay Hollow one mile north. The whole depression is filled with a quartz conglomerate over a thin bed of cherty breccia in some of the deeper places. This filling rises over the sides of the valley but may form only a thin coating. Within the channel the thickness ranges from 160 feet at the west to 250 feet at the east.

Another tributary is outlined by a line of conglomerate capped hills extending west across Marion, Union and into Scioto Township of Pike County. After turning south across the pre-glacial valley of the Teays River conglomerate ledges rise 80 feet above the valley of Dry Run and 67 feet at the White Gravel Church. Beyond that place the conglomerate thins, a result evidently of a widening of the channel and a lowering of its gradient.

MEETING OF THE BIOLOGICAL CLUB.

Orton Hall, Dec. 7, 1914.

The meeting was called to order by the President, Dr. Seymour, and the minutes of the previous meeting were read and approved.

Dr. F. H. Brown, Miss Mary Oliver, Don B. Whelan, and D. M. DeLong were elected to membership in the society.

The names of H. D. Chase, Vernon Haber, W. T. Owry, R. C. Smith, F. H. Smith, J. R. Smith, W. S. Krout, H. J. Reinhard, D. D. Leyda, R. C. Baker, W. E. Laughlin, C. W. Hauck, John Eckert, Oliver Gossard, J. R. Stear, R. A. Knouff, E. H. Baxter, F. F. Searle, H. G. Cutler, and Adolph Waller were proposed for membership in the club.

The program of the evening consisted of two interesting papers: "The Inheritance for Yellow, White, and Cream Colors in Guinea Pigs" by Prof. Barrows and "Some New Ideas in Fertilization" by Prof. Landacre.

The club then adjourned.

Carl J. Drake, Secretary.

"Plant Breeding"[1] by Professor L. H. Bailey has been revised and brought up to date by Professor A. W. Gilbert of Cornell University. The book as it now appears is a great improvement over previous editions. One of its very commendable features in Appendix E which gives specific directions for laboratory and field work. Altho quite thoroly revised there are still some of the ear marks of the old views left which do not always coincide with the newer ones. It would perhaps have been better to have written an entirely new book.

There are a few errors which might have been avoided if the copy had been read more closely. On page 112, pumpkin is given as Cucurbita pepo and the squash as Cucurbita maxima, while on page 129 squashes are said to be Cucurbita pepo.

It is very unfortunate that pollen-grains are contrasted with eggs cells, as if the word pollen-grain were synonymous with sperm cell. Such a mistake in terminology, as has been pointed out by various writers, can only lead to confusion. Some gymnosperms have as high as 16 sperms in the male gametophyte. Each one of the two sperms of the pollen grain of angiosperms has a separate effect in heredity, one going to fertilize the egg and the other uniting with the two polar nuclei. How could one possibly make clear the checkered arrangement of the endosperm of hybrid corn, if no distinction is made between a male gametophyte of three cells and the single cell of a true spermatozoid?

When it comes to a matter of plant genetics no middle ground is possible; the old morphological terminology is false, as it was invented when fundamentally erroneous notions were held in regard to many of the essential structures of plants.

What we need, is to follow the terminology of modern cytologists and morphologists and all confusion will be avoided.

J. H. S.

1. Plant Breeding, by L. H. Bailey. New edition revised by Arthur W. Gilbert, Ph. D., professor of plant-breeding, in the New York State College of Agriculture at Cornell University. Pp. xviii+474; 113 illus. The Rural Science Series (edited by L. H. Bailey); The Macmillan Company, New York, 1915. Price $2.00 net.

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THE FISH-FEEDING COLEOPTERA OF CEDAR POINT.

H. E. JAQUES.

The writer made numerous observations of the fish feeding Coleoptera of Cedar Point during a period of eight weeks in the summer of 1912. In the following summer the work was taken up in a more systematic way and efforts made to secure data as to the number of species feeding on fish, their life histories, food habits, and other items of interest.

A recital of the numerous experiments that resulted in no definite knowledge would be both tedious and unprofitable. To this class then will be assigned the repeated efforts to secure eggs of the several species by dissection and breeding cages, and the many attempts to carry larval forms thru the remaining stages to adulthood.

Fish of various sizes and species are cast up by the waves on the lake side of the Point at more or less regular intervals in large quantities. Herms* in June, 1906, counted and weighed the fish cast up from 5 P. M. to 4 A. M. of one night, along a mile of this beach. His report shows a total of 538 fish representing some 8 or 10 species and totaling in weight 20.38 kilograms. In a few days these are reduced to bones and scales. The forces exerting the most active part in this act of sanitation are the drying influence of the sun, the absorbing power of the sand, the occasional bird visitor, and the very abundant forms of insect life

* Herms. Jour. Exp. Zool. IV, 45-83.

always found associated with the dead fish. Members of the Diptera, Coleoptera, Lepidoptera, and Hymenoptera have been observed in this association. The first two orders named are by far the most abundant, both in number of species and individuals. Of these the Diptera usually far outnumber the Coleptera in number of individuals, the only four species*, ***Lucilia caesar*** Linne, ***Compsomyia macellaria*** Fabr.; ***Sarcophaga sarraceniae*** Riley, and ***Sarcophaga assidua*** Walker, all members of the family Sarcophagidæ, are at all common. Diptera are universally present in the larval stage and usually in large number while with few exceptions, as mentioned, later, the Coleoptera found associated with the dead fish are in the adult stage. This makes the Diptera of first importance in removing the frequent accumulation of fish. Twenty-one species of Coleoptera in all, as follows, were found by the writer associated with dead fish and apparently feeding thereon:

Silphidæ

Necrophorus americanus Oliv.
Necrophorus orbicollis Say.
Necrophorus tomentosus Weber
Silpha surinamensis Fab.
Silpha inæqualis Fab.
Silpha americana Linn.

Staphylinidæ

Leistotrophus cingulatus Grav.
Creophilus villosus Grav.
Philonthus aeneus Rossi.

Dermestidæ

Dermestes caninus Germ.
Dermestes vulpinus Fab.

Histeridæ

Hister imunis E.
Hister abbreviatus Fab.
Saprinus lugens Erichs.
Saprinus pennsylvanicus Payls.
Saprinus assimilis Payls.
Saprinus fraternus Say.
Saprinus patruelis Lec.

Mitidulidæ

Omosita colon Linn.

Scarabæidæ

Onthophagus hecate Panz.
Trox scabrosus Beauv.

It was thought that the Coleopterous scavangers might be most active at night while retiring to more secluded hiding places by day. This was disproven by night trips with lantern, when Coleoptera were found in no greater numbers than by day, except Trox scabrosus Beauv. This last named species was usually found in large numbers clumsily wading thru the sand, and leaving their paths as irregular lines running in every direction. When approached they play "possum" and easily pass for pebbles. Their frequency at fish by night, however, did not show a marked increase over that of the day.

One or more of the larval forms of this species may be found in their burrows in the sand a few inches under many of the fish, and are sometimes found under boards on the fish strewn beach. None were observed feeding, however, either by night or day.

Early in the period of observation it was found that fish removed from the beach to shaded places under the trees drew coleoptera in much larger number and representing more species,

than fish remaining on the beach. For a period of six weeks a number of "traps" made by covering several fish with boards were maintained at different places on the Point, and kept in continual operation by frequently adding fresh supplies of fish. Other traps similar in structure were moved from place to place every few days. It was found that location had much to do with the number of individuals present, and that the traps maintained in regions of the deepest shade were most productive. Within certain limits the number of individuals and species increased with the age of the trap. In these traps larval forms of the families, Silphidæ, Staphy-linidæ and Dermestidæ were frequent. In the aggregate members of the Histeridæ were represented in larger numbers as adults than any other family, but their larvæ were never present.

During the early morning of July 25th, while making a trip along the beach two carp were found, weighing about two pounds each, not more than fifty feet apart, that had just been cast up by the waves Over one a box 14″x18″ was turned, protecting the fish from the sun and the birds. The afternoon of the 28th the box was removed and the sand for a radius of two feet from the fish and to a depth of about a foot was carefully sifted and the astonishing number of 1310 adult Hister beetles, practically all of them Saprinus pennsylvanicus Payk were taken. Most of these we found a few inches under the fish in the sand made wet with the juices. Accompanying these were nine adult Dermestes caninus Germ. To these might be added the five beetles taken from the stomach of a small toad found under the box buried in the sand. Only one of the five, however, was a fish feeder, it being Saprinus pennsylvanicus. Hundreds of Dipteron larvæ were present, but not the slightest trace of beetle larvæ save one of Trox scabrosus.

The sand around the unprotected fish of some size and kind, already mentioned, was sifted but the result was the same as that found at other unprotected fish examined at different times. Of the beetles found at such times the Histers predominated in numbers with an occasional member of the Staphylinidæ and one or two larval forms of Trox scabrosus. No other larval forms of coleoptera were found, the fly larvæ were always found in large number. The total number of beetles found in these unprotected fish never exceeded 100 and averaged about 50.

Some writers suggest that the Hister beetles instead of being carrion feeders may be predaceous, feeding on the larvæ of flies universally present in carrion. Several experiments in which adult Histers were confined with fly larvæ for several days with and without other food failed to show one case where a fly larva sacrificed its life to the Hister beetles. On July 31st, however, the writer saw two adults of Silpha americana eating fly larvæ

about 3 mm. in length. This feeding continued for some time under observation. As they walked about they would pass exposed parts of the fish to eat at piles of larvæ. Two or three larvæ would be taken up at one time and eaten with apparent relish.

By way of comparing fish and other carrion as food for these forms, the body of a cat was used as bait in a trap. When examined 17 Silpha americana were taken while a few others escaped. In the same morning but two beetles of the same species were found in a trap baited with fish twice as bulky in quantity as the cat and located in adjacent territory.

From these rather rambling observations the following conclusions may be drawn.

1. Coleoptera are of only secondary consideration in reducing the fish debris of Cedar Point.

2. They are most active in damp shaded places and resort to fish of the sun-heated beach only of necessity.

3. While associated with the fish on the beach they are eaten in large quantities by the sand pipers and other shore birds and doubtless must draw new recruits from more protected places to preserve their balance.

4. The larval forms, the Trox excepted, if fish feeding do not appear on the beach during June and July.

5. With a number of these forms fish is not their first choice as food.

6. The Hister beetles on the beach probably feed on neither the flesh of fish nor fly larvæ but on the juices escaping from the decaying fish.

RECORDS OF GUATEMALAN HEMIPTERA-HETEROPTERA WITH DESCRIPTION OF NEW SPECIES.*

Herbert Osborn and Carl J. Drake.

The Guatemalan Hemiptera-Heteroptera listed and the new species described in this paper were collected by Prof. Jas. S. Hine during the winter of 1905. Altho most of the records recorded herein are found in the "Biologia Centrali Americana" and confirm the records of Messrs. Distant and Champion, several are new to Guatemala and Honduras, some to Central America, and a few to science.

Nearly all of the aquatic and semi-aquatic Heteroptera were turned over to Mr. J. R. de la Torre Bueno who has published a preliminary paper[1] on the same. A paper[2] covering part of the Homoptera was published by the senior author, but some of this material remains in the university collection for further study.

Family Corixidæ.

Tenagobia socialis F. B. White.

One specimen: Los Amates, Guatemala, Feb. 18th, 1905.

Family Nepidæ.

Ranatra fusca Palisot de Beauvois.

Two typical specimens, taken at Los Amates, Guatemala, Jan. 16th, 1905.

Family Belostomidæ.

Belostoma annulipes Herrich-Schaffer.

One specimen: Los Amates, Guatemala, Jan. 16th, 1905.

Abedus breviceps Stal.

One specimen: Gualan, Guatemala, Jan. 14th, 1905.

Zaitha anura Herrich-Schäffer.

One specimen: Los Amates, Guatemala, Jan. 16th, 1905.

Zaitha fusciventris Dufour.

One specimen: Los Amates, Guatemala, Feb. 16th, 1905.

Family Gelastocoridæ.

Pelogonus perbosci Guerin.

Several specimens from Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 16th; Santa Lucia, Feb. 2d, 1905.

Gelastocoris oculatus Fabricius.

Five specimens of this common and widely distributed species from Guatemala; Gualan, Jan. 14th; Aguas Callientes, Jan. 28, 1905.

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* Contributions from the Department of Zoology and Entomology of the Ohio State University, No. 40.

[1] Ohio Naturalist, Vol. VIII, No. 8, p. 370-382.

[2] Ohio Naturalist, Vol. IX, No. 5, p. 457-466.

Family Saldidæ.

Salda opacipennis Champion.

A large series, evidently a common insect in Guatemala: Gualan, Jan. 14th, 1905. The female is larger and broader than the male and has a white spot at the base of the elytra. The genital segment is slightly produced in the middle; whitish on the borders and most of the posterior third.

Family Reduviidæ.

Saica apicalis n. sp.

Similar to *S. fuscipes* Stal, but with the apices of the femora, base of tibiae, and spines on the pronotum, prothorax, and scutellum vermillion-red.

Antennæ as long as the body; basal segment nearly as long as the other three conjoined; second segment one-third as long as the first; third segment twice the length of the second; fourth one-half the length of the third; first and second segments straight; the third and fourth slender and curved. Anterior and intermediate legs nearly equal in length; posterior legs longer with the femora passing the end of the abdomen. Legs and antennæ clothed with long fine hairs. The anterior femora with an outer and inner row of setæ quite regularly placed.

Color. Head, thorax, abdomen, rostrum, base of antennæ, coxæ, trochanter, base and apex of femora, costa, veins of hemelytra and base of tibiæ vermillion-red. Antennæ, femora except base and apex, tibiæ except base and apex, posterior portion of abdomen, blackish or infuscated. Legs blackish, apex of tarsi and tibiæ of fore and middle legs fusco-ochraceous. Tarsi only of posterior legs fusco-ochraceous.

♂. Penultimate segment short and surpassed by the margin of the antepenultimate. Terminal segment tumid, with long incurved claspers, densely haired, acute at tip.

♀. Genital segments triangular, rounded below, with a central supra-anal plate covering the larger part. The lateral lobes narrow, their apices and borders of vulvar openings densely haired.

Length ♂ and ♀ 13 to 13.5 mm, width ♂ and ♀ 2 mm.

One ♂ and four ♀, taken at Los Amates, Guatemala, Feb. 18th to 28th, 1908.

?Stenopoda culiciformis Fabricius.

One nymph, taken Jan. 15th, 1905 at Gualan, Guatemala.

Conorhinus dimidiatus Latreille.

One specimen, belonging to the variety *C. maculipennis* Stal as recognized by Champion: Santa Lucia, Guatemala, Feb. 1st, 1905.

Sirthenea carinata Fabricius.

One adult and two nymphs from Guatemala: Morales, March 8th; Gualan, Jan. 14, and Feb. 15, 1905. This conspicuous and well-marked species ranges from Ohio to the southern part of South America.

Apiomerus moestus Stal.

One specimen, taken at Puerto Barrios, Guatemala, March 3rd, 1905.

Zelus rubidus Lepelletier et Serville.

One specimen, taken Jan. 14th, 1905 at Gualan, Guatemala.

Zelus cervicalis Stal.

♂ and ♀, taken Jan. 14th, 1905 at Gualan, Guatemala. This seems to be a rather variable insect. In color the ♂ agrees with *Z. lævicollis* Champion but lacks the tooth on the lateral angles of the pronotum. In the ♀ the color markings on the post-ocular portion of the head are not very distinct and there are no spines on the pronotum; the legs are much darker than in the male. A large series of these two forms will probably prove *Z. lævicollis* Champion to be a variety of this species with a slightly prominent tooth on the lateral angles of the pronotum.

Ricolla simillima Stal.

A large series of this common insect from Guatemala: Gualan, Jan. 14th; Los Amates, Jan. 17th and Feb. 18th to 28th; Puerto Barrios, March 3d to 14th. One specimen, taken at San Pedro, Honduras, Feb. 21st, 1905.

Repipta taurus Fabricius.

Five specimens from Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 18th; Puerto Barrios, March 3d, 1905.

Repipta flavicans Amyot and Serville.

Three specimens from Guatemala; Santa Lucia, Feb. 2d; Puerto Barrios, March 3d, 1905. One specimen, collected at San Pedro, Honduras, Feb. 21st, 1905.

Repipta nigronotata Stal.

One specimen, taken March 3d, 1905 at Puerto Barrios, Guatemala.

Atrachelus cinereus Fabricius.

Four specimens from Guatemala: Gualan, Jan. 14; Santa Lucia, Feb. 2d, 1905.

Sinea sp.

One nymph; Los Amates, Guatemala.

Sinea caudata Champion.

One specimen, taken at Los Amates, Guatemala, Feb. 2d, 1905.

Sinea raptoria Stal.

Two specimens, taken at Gualan, Guatemala, Jan. 14, 1905.

Family Emesidæ.

Emesa longipes De Geer.

Five specimens from Guatemala: Gualan, Jan. 14th; Mazatenango, Feb. 3d, 1905.

Ghilianella ignorata Dohrn.

One specimen, taken Feb. 5th, 1905 at Los Amates, Guatemala.

Stenolæmus spiniventris Signoret.

One specimen: Los Amates, Guatemala, Jan. 17th, 1905. This species is apparently very rare and, although not hitherto recorded for Guatamala, this confirms the record of its occurrence in Central America.

Family ANTHOCORIDÆ.

Asthenidea nebulosa Uhler.

Two specimens from Guatemala: Los Amates, Feb. 25th, 1905.

Family CAPSIDÆ.

Trachelomiris oleosus Distant.

A large series of this common insect. Guatemala: Santa Lucia, Feb. 2d; Mazatenango, Feb. 3rd; Gualan, Feb. 13th; Los Amates, Feb. 18th and March 18th to 28th; Puerto Barrios, March 3d, 1905 Honduras: Feb. 21st to March 8th, 1905.

Jobertus chryselectrus Distant.

Two specimens from Guatemala: Santa Lucia, Feb. 2d; Los Amates, Feb. 25th, 1905.

Creontiades rubrinervus Stal.

One specimen from Guatemala: Santa Lucia, Feb. 2d, 1905.

Eioneus bilineatus Distant.

One specimen, taken at Los Amates, Guatemala, Jan. 17th, 1905.

Resthenia latipennis Stal.

A fine series from Guatemala: Gualan, Jan. 14th; Santa Lucia, Feb. 2d, 1905. One specimen from Honduras; San Pedro, Feb. 21st, 1905. The series contains the typical and varietal forms as figured by Distant, also specimens with the pale coloration being more ochraceous than red. The different color patterns gradually merge into each other.

Resthenia vitticeps Stal.

One specimen, taken March 3d, 1905 at Puerto Barrios, Guatemala.

Resthenia persignanda Distant.

Nine specimens from Guatemala: Santa Lucia, Feb. 2d, 1905.

Compsocerocoris annulicornis Reuter.

Three specimens of this very variable species. Guatemala; Los Amates, Feb. 25th, 1905. Honduras; Feb. 21st, 1905.

Neurocolpus mexicanus Distant.

One specimen, taken at Gualan, Guatemala, Jan. 14th, 1905.

Pappus breviceps n. sp.

Approaching *P. sordidus* Distant, but with the third and fourth antennal segments very short. Length 4.5 mm. Width 1.25 mm.

Head short, deflected; tylus prominent, polished black; eyes prominent. Pronotum slightly constricted in front of the middle; with two elevated lobes anteriorly, scarcely punctured; posterior portion coarsely punctate. Scutellum minutely transversely rugulose-punctate. The clavus and corium coarsely punctate. Posterior part of pronotum, scutellum, and hemelytra with sparse, minute, decumbent hairs. Antennæ with the first segment enlarging at the apex, scarcely longer than the head; second segment moderately thick, slender at base, and slightly incrassated towards apex, distinctly pilose, and three times as long as the first; third segment enlarging at the apex, much shorter than the first; fourth segment inflated, subequal to the third in length.

COLOR. Antennæ, eyes, and spot on the meta- and mesopleura black. Head, pronotum, and corium ochraceous and shaded with fuscous. The front of the head with about six transverse reddish arcs. Prothorax with a transverse band before the middle, in the depression reddish-fuscous; a submarginal band at base and extending forward on the sides fuscous. Scutellum blackish at the sides, with a central obscure ochraceous stripe. Membrane fuscous. Legs yellow; femora with a reddish-fuscous band near the apex; an indistinct band beyond the middle of the tibiæ and the tarsi fuscous.

Described from a single example, taken at Los Amates, Guatemala, Feb. 18th, 1905.

This species seems to be included in the genus *Pappus* as described by Distant, but differs somewhat in the proportional length of the antennal segments and in the shorter and more rounded front of the head.

Garganus albidivittis Stal.

A large series from Guatemala: Santa Lucia, Feb. 2d; Mazatenango, Feb. 3d; Los Amates, Feb. 18th to 28th. Honduras; San Pedro, Feb. 21st, 1905.

Genus **Isoproba** gen. nov.

Head globose and connected to the prothorax by a narrow neck; face strongly deflected. Antennæ slightly setose; first segment shorter than the head (about two-thirds as long); second segment slightly thickened, four times as long as the first, or about equal to the third and fourth conjoined. Rostrum reaching the intermediate coxæ. Prothorax narrowed in front and flaring behind; the posterior border concave; dorsal surface gibbous in front and with transverse depression behind the middle. The base of the scutellum tumid. Elytra semitransparent and set with short hairs. Type of genus *Isoproba picea*.

This genus can be separated readily from *Paraproba* Distant and allied genera by the more globose head and the peculiar shape of the prothorax.

Isoproba picea n. sp.

Head globose, slightly wider than long. Eyes not prominent, forming part of the contour of the head; tylus slightly projecting, but strongly deflected. Antennæ with the first segment short, slender at base; second segment enlarging slightly towards the apex; third and fourth segments slender.

COLOR. General color jet black; elytra and legs pallid. Head, second segment of antennæ, thorax, scutellum, and abdomen beneath shining pitchy black. First segment of antennæ pallid, except at base black; second, third, and fourth segments black. Elytra semitransparent, on the inner border of the corium and clavus pallid and infuseated; the apex of corium and clavus, the margin of the cuneus, and the membrane faintly smoky. The legs pallid. Length, 2.75 mm, width .34 mm.

One specimen, taken at Puerto Barrios, Guatemala, March 3d, 1905.

Lygus pratensis Linnaeus.

Two specimens of this widely-distributed and very variable species from Guatemala: Santa Lucia, Feb. 2d, 1905.

Lygus sallaei Stal.

Three specimens from Guatemala: Los Amates, Santa Lucia, Feb. 2d; Gualan, Feb. 14, 1905.

Lygus scutellatus Distant.

A good series from Guatemala: Los Amates, Jan. 17th, and Feb. 25th; Santa Lucia, Feb. 2d; Puerto Barrios, March 3d, 1905.

Lygus lanuginosus Distant.

Five specimens from Guatemala: Los Amates, Santa Lucia, Feb. 2d, 1905.

Lygus cuneatus Distant.

A good series from Guatemala; Los Amates, Jan. 17th; and Feb. 25th; Santa Lucia, Feb. 2d; Puerto Barrios, March 3d, 1905.

Poecilocapsus ornatulus Stal.

One specimen, taken Feb. 3d, 1905 at Mazatenango, Guatemala.

Horcias plausus Distant.

Four specimens from Guatemala: Los Amates, Jan. 17th and Feb. 25, 1905.

Eccritotarsus pallidirostris Stal.

A large series from Guatemala: Santa Lucia, Feb. 2d, 1905.

Eccritotarsus incurvus Distant.

One specimen, taken at Los Amates, Guatemala, Jan. 17th, 1905.

Eccritotarsus bulbosus n. sp.

Near *E. incurvus* Distant, but differing by its smaller size and the two conspicuous inflated bulbous enlargments on the pronotum. Antennæ, legs, membrane, and two spots on the margin of the corium white. Length 2.5 mm. width .9 mm.

Head transverse; eyes prominent; face deflected. Antennæ with the first segment longer than the head and slightly shorter than the second; third and fourth segments absent. Pronotum elevated in two conspicuous bulbous enlargments equal to the depth of the body, separated by a deep central furrow, leaving a narrow collar in front, and slightly overhanging the scutellum behind. Head and pronotum roughly punctate. Elytra with the costal margins convex, whitish, semitransparent, and with a black

spot behind the middle and another near the apex; cuneus transparent; narrow borders of cuneous and cell of membrane dusky. Legs distinctly whitish; tarsi and claws dusky. Genital segments whitish.

Three examples from Guatemala: Gualan, Jan. 14th, 1905; Santa Lucia, Feb. 2d, 1905.

Eccritotarsus atratus Distant.

A good series from Guatemala: Gualan, Jan. 14th; Santa Lucia, Feb. 2d; Los Amates, Feb. 18th to 28th, 1905.

Eccritotarsus nocturnus Distant.

Two specimens, taken at Gualan, Guatemala, Jan. 14th, 1905.

Eccritotarsus procurrens Distant.

A large series from Guatemala: Gualan, Jan. 14th; Los Amates, Jan. 17th, and Feb. 25th; Santa Lucia, Feb. 2d; Puerto Barrios, March 3d, 1905.

Annona bimaculata Distant.

A large series from Guatemala; Los Amates, Jan. 17th, Feb. 18th to 28th; Santa Lueia, Feb. 2d, 1905.

Annona decoloris Distant.

One specimen, taken at Santa Lucia, Guatemala, Feb. 2d, 1905.

Neofurius tabascœnsis Distant.

One specimen, taken at Mazatenango, Guatemala, Feb. 3d, 1905.

Bibaculus modestus Distant.

Eight specimens from Guatemala: Santa Lucia, Feb. 2d; Puerto Barrios, March 3d, 1905. As noted by Distant, this is a variable species. Three specimens are typical *modestus;* the others have the black markings brownish and more or less indistinct.

Neosilia pulchra Distant.

One specimen, taken Feb. 2d, 1905 at Santa Lucia, Guatemala.

Neosilia viduata Distant.

A good series from Guatemala; Los Amates, Jan. 17th and Feb. 18th to 28th, 1905.

Jornandes parvus Distant.

Two specimens from Guatemala: Los Amates, Feb. 18th and 25th, 1905. The two examples differ from Distant's description in having the outer half of the first antennal segment swollen and black.

Lampethusa anatina Distant.

A large series of this variable species from Guatemala: Los Amates, Jan. 17th and Feb. 25th; Santa Lucia, Feb. 2d; Mazatenango, Feb. 3d; Puerto Barrios, March 3d, 1905. One specimen from Honduras; Feb. 21st, 1905.

Family Phymatidæ.

Macrocephalus notatus Westwood.
Six specimens from Guatemala: Puerto Barrios, March 3d, 1905.

Phymata erosa Linnæus.
One specimen, belonging to the variety *fasciata* Gray, from Guatemala: Gualan, Jan. 14th, 1905.

Family Aradidæ.

Hesus flaviventris Burmeister.
One specimen, taken March 3d, 1905 at Puerto Barrios, Guatemala.

Dysodius lunatus Fabricius.
Two specimens from Guatemala: Puerto Barrios, March 3d; Morales, March 8th, 1905.

Family Tingitidæ.

Gargaphia nigrinervis Stal.
Two specimens from Guatemala: Gualan, Jan. 14th, 1905.

Leptostyla lineata Champion.
One example from Guatemala: Los Amates, Feb. 18th, 1905.

Teleonemia atratra Champion.
One ♂, Los Amates, Guatemala, Jan. 17th, 1905.

Atheas nigricornis Champion.
Five specimens from Guatemala: Gualan, Jan. 14th, 1905.

Acanthochila armigera Stal.
One specimen, taken at Los Amates, Guatemala, Feb. 18th, 1905.

Monanthia monotropidia Stal.
One example from Guatemala: Los Amates, Feb. 18th, 1905.

Family Lygæidæ.

Oncopeltus cingulifer Stal.
Five specimens from Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 18th to 28th, 1905. Two examples from Honduras; San Pedro, Feb. 21st to 28th, 1905.

Lygæus pyrrhopterus Stal.
One specimen, taken March 8th, 1905, at Panzos, Guatemala.

Nysius spurcus Stal.
A good series from Guatemala: Gualan, Jan. 14th; Los Amates, Jan. 17 and Feb. 18th to 28th, 1905.

Ninus notabilis Champion.

Two specimens from Guatemala: Gualan, Jan. 14th; Puerto Barrios, March 3d, 1905.

Ischnodemus præcultus Distant.

One specimen, taken at Puerto Barrios, Guatemala, March 3d, 1905.

Ischnodemus cahabonensis Distant.

Three specimens from Guatemala: Los Amates, Jan. 17th; Santa Lucia, Feb. 2d, 1905.

Blissus leucopterus Say.

One example, taken at Los Amates, Guatemala.

Geocoris lividipennis Stal.

One specimen, taken at Gualan, Guatemala, Jan. 1st, 1905.

Geocoris punctipes Say.

One specimen from Guatemala: Los Amates, Feb. 25th, 1905.

Pachygrontha compacta Distant.

One specimen, taken March 3d, 1905, at Puerto Barrios, Guatemala.

Davila concavus Distant.

Two specimens from Guatemala: Santa Lucia, Feb. 2d, 1905.

Myodocha unispinosa Stal.

Three specimens from Guatemala: Gualan, Feb. 15th and 19th; Los Amates, Feb. 25th, 1905.

Heræus cincticornis Stal.

One specimen, taken at Los Amates, Guatemala.

Pamera parvula Dall.

Ten specimens from Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 16th to 28th; Puerto Barrios, March 3d, 1905.

Pamera vicinalis Distant.

Three specimens from Guatemala: Los Amates; Gualan, Jan. 14th and Feb. 13th, 1905.

Pamera bilobata Say.

Four specimens from Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 18th to 28th, 1905.

Pamera dallasi Distant.

One specimen, taken at Puerto Barrios, Guatemala, March 3d, 1905.

Pamera globiceps Stal.

Two examples, taken Feb. 2d, 1905 at Santa Lucia, Guatemala.

Gonatus divergens Distant.

Two specimens from Guatemala: Gualan, Feb. 14th; Los Amates, Feb. 18th, 1905. The ♀ specimen is apparently immature and of a light color probably due to the fact that it was killed soon after the last ecdysis took place.

The ♂ referred with some doubt to this species is smaller than indicated by Distant's description. With the material on hand, we do not feel warranted in making a new species of this specimen. It is of a uniformly brown color with the posterior angles of the pronotum and the veins of the corium of lighter brown. Head slightly wider than long; eyes rather coarsely granulate. Antennæ with the second segment one-third longer than the third; third segment slightly longer than first; fourth wanting. Pronotum much wider than long; sides with a simple carina; anteriorly suddenly contracted to width of head; posterior border slightly emarginate. Scutellum triangular, large, elevated next to the pronotum, flattened on the disc, obsoletely carinate at the apex. Head finely punctulate except at the base. Pronotum more coarsely punctulate, but with polished and faintly punctate areas on the anterior disc and the posterior angles. Scutellum, except the polished base, and hemelytra uniformly punctate. Length 4 mm., width 1.75 mm.

Family Pyrrhocoridæ.

Dysdercus mimus Say.

Two specimens from Honduras: San Pedro, Feb. 21st to March 8th, 1905.

Dysdercus albidiventris Stal.

A common and very variable insect in Guatemala: Gualan, Jan. 14th; Los Amates, Feb. 18th to 25th, 1905.

Family Coreidæ.

Pachylis sp.

Five nymphs from Guatemala: Gualan, Jan. 14th; Puerto Barrios, March 3d, 1905.

Stenoscelidea ænescens Stal.

One specimen, taken at Los Amates, Guatemala, Jan. 16th, 1905.

Capaneus odiosus Stal.

Four specimens from Guatemala: Mazatenango, Feb. 3d; Puerto Barrios, March 3d, 1905.

Plapigus circumcinctus Stal.

Three specimens from Guatemala: Los Amates, Jan. 17th; Puerto Barrios, March 3d, 1905.

Madura perfida Stal.

Two specimens from Guatemala: Los Amates, Feb. 18th, 1905.

Madura longicornis Stal.

One example, taken March 3d, 1905 at Puerto Barrios, Guatemala.

Zicca commaculata Distant.

A good series from Guatemala: Los Amates, Jan. 17th, and Feb. 18th to 28th, 1905. Two specimens from Honduras: San Pedro, Feb. 21st, 1905.

Zicca taeniola Dall.

A large series from Guatemala, evidently a common insect. Los Amates, Jan. 17th and Feb. 18th to 28th; Puerto Barrios, March 3d, 1905. Honduras; March 21st, 1905.

Hypselonotus concinnus Dallas.

One specimen, taken at Puerto Barrios, Guatemala, March 3d, 1905.

Savius dilectus Stal.

One specimen from Guatemala: Feb. 18th, 1905.

Hyalymenus pulcher Stal.

Four specimens from Guatemala: Los Amates, Feb. 25th; Puerto Barrios, March 3d, 1905.

Hyalymenus tarsatus Fabricius.

One specimen, taken March 3d, 1905 at Puerto Barrios, Guatemala.

Alydus pallescens Stal.

One specimen from Guatemala: Gualan, Feb. 13th, 1905.

Cydamus borealis Distant.

One example, taken at Los Amates, Guatemala, Jan. 1st, 1905.

Leptocorisa filiformis Fabricius.

Numerous specimens from Guatemala: Santa Lucia, Feb. 2d; Mazatenango, Feb. 3d; Puerto Barrios, March 3d, 1905.

Corizus sidæ Fabricius.

A fine series from Guatemala: Gualan, Feb. 13th; Los Amates, Feb. 21st to March 8th, 1905. Honduras: San Pedro, Feb. 21st to March 8th, 1905.

Family Berytidæ.

Jalysus mollistus Distant.

Four specimens from Guatemala: Santa Lucia, Feb. 2d, 1905.

Family Pentatomidæ.

Podisus thetis Stal.

Two specimens: Los Amates, Guatemala, Feb. 21st, 1905; San Pedro, Honduras, Feb. 25th, 1905.

Mormidea ypsilon Linnæus.

Several specimens from Guatemala: Los Amates, Jan. 17th and Feb. 18th to 28th; Gualan, Jan. 14th; Puerto Barrios, March

3d, 1905. The specimens all belong to the variety *M. inermis* Dall. as recognized by Distant. A large series of this species from British Guiana shows about every gradation from the strongly spinous to the non-spinous pronotal angles.

Mormidea pictiventris Stal.

A fine series from Guatemala: Puerto Barrios, March 3d, 1905.

Euschistus crenator Fabricius.

A full series, evidently rather abundant in Central America. Guatemala: Gualan, Feb. 15th; Los Amates, Feb. 25th; Puerto Barrios, March 3d and 14th, 1905. Honduras: San Pedro, Feb. 21st to March 8th, 1905. This is a rather variable species. Three specimens from Gualan have the humeral angles less produced and not acutely angled; the lateral border of pronotum denticulate anteriorly, smooth posteriorly (without any denticulations); scutellum at apex with a very narrow whitish border.

Proxys albo-punctulatus Palisot de Beauvois.

Two specimens: Santa Lucia, Guatemala, Feb. 2d, 1905.

Proxys victor Fabricius.

Four specimens from Guatemala: Santa Lucia, Feb. 2d, and Los Amates; Feb. 18th and 25th, 1905.

Proxys punctulatus Palisot de Beauvois.

Two specimens: San Pedro, Honduras, Feb. 21st, 1905. The three above species belonging to this genus are closely related. The rather arbitrary separation on color of legs seems barely warranted, but we have followed Stal and Distant in recognizing them.

Thyanta perditor Fabricius.

Three specimens from Guatemala: Gualan, Jan. 14th, Los Amates; Feb. 18th, and Puerto Barrios, March 3d, 1905.

Nezara marginata Palisot de Beauvois.

Two specimens: Los Amates, Guatemala, Jan. 16th, 1905.

Banasa albo-apicata Stal.

One specimen: Los Amates, Guatemala, Feb. 18th, 1905. Hitherto recorded for Central America (Honduras) on the authority of Stal and its occurrence seems rather rare.

Piezosternum subulatum Thumb.

One specimen, taken at Morales, Guatemala, March 8th, 1905. This species has been recorded for Panama, Columbia, and Antilles but not for Guatemala.

Edessa taurina Stal.

One specimen: Puerto Barrios, Guatemala, March 3d, 1905.

Edessa affinis Stal.

Eight specimens: Puerto Barrios, Guatemala, March 3d, 1905.

Edessa rixosa Stal.

Two specimens from Guatemala: Los Amates; Feb. 25th and Morales; March 8th, 1905.

Edessa rufomarginata DeGeer.

A common species for a large area in Central and South America. Guatemala: Los Amates, Feb. 18th; Puerto Barrios, March 5th to 11th; Morales, March 8th; Panzos, March 18th, 1905.

Stiretrus anchorago Fabricius.

Two specimens, much smaller than the typical specimens found in United States, but otherwise similar: Puerto Barrios, Guatemala, March 3d, 1905.

Family Cydnidæ.

Pangæus piceatus Stal.

One specimen, taken at Gualan, Guatemala, Feb. 15th, 1905.

Family Thyreocoridæ.

Thyreocoris guttiger Stal.

Four specimens: Los Amates, Guatemala, Feb. 10th to 18th, 1905. Three specimens seem to be typical *T. guttiger* and the other is intermediate between this species and *T. quadrisignatus* Stal. These two species will probably merge with a more extended series.

VARIATION IN THE SIZE OF RAY PITS OF CONIFERS.*

Forest B. H. Brown.

Since Haeckel proposed the word Ecology in 1886, there has been an ever growing interest in the influence which environmental factors may have in determining the form and structure of plants. "Anatomy, particularly stimulated by Haberlandt, has recently been greatly enriched by numerous researches dealing with the question of the harmony between structure and environment."[1] Trees of the same species, but grown under different conditions, will show differences in the structure of their woody tissues that materially affect the durability, strength, and other properties of the wood. In a general way, many of such structural differences have been related to the conditions under which the tree was grown.

To some extent, at least, the physical factors may influence the structure of wood. Cieslar[2] found that certain conifers would form "Rotholz," a tissue of great strength under compression, due to the mechanical influence of a one-sided crown or the weight of a branch. But since one of the main purposes of the woody elements of a tree is to conduct and store the products of assimilation, and to convey the watery solutions, gathered by the roots, to the leaves and other parts where they may be needed, it may be inferred that factors more directly related to the vital processes of the tree will also be more directly related to structural variations.

Of the tissues which go to make up the woody part of the stem of coniferous trees, the medullary ray is one of the most complex, in both its structural and functional aspects. While they make up only 4-8 % of the volume of the wood, their height and width is so small that often over 2,500 rays may be counted in one sq. cm. on the tangential surface (Fig. 1). The average volume of a typical coniferous ray shown in this plate is but one twentieth that of a fine silk thread. None the less, the ray of Picea and Larix, the genera selected for comparison in this paper, is composed of at least two kinds of tissue with an accompanying difference in function (Fig. 2). At the margins are the ray tracheids (r.t.), which communicate with the adjacent wood tracheids by means of bordered pits. "Their purpose is to facilitate the transfer of water radially between the tracheids."[3] Distinguished from the

*Contribution from the Botanical Laboratory of the Ohio State University, No. 90.

1. Warming. 1909. Ecology of Plants, p. 3.
2. Centralblatt f. d. gesamte Forstwesen. Apr., 1896.
3. Strasburger. 1908. Bonn Text-Book, p. 140.

ray tracheids are the ray parenchyma cells with semi-bordered pits (s. b. p.) upon their lateral walls and simple pits upon their end walls (e. w.). These cells make up the storage tissue of the ray, in which the products of assimilation are conducted and stored. Still more complex in structure and function are the rays which

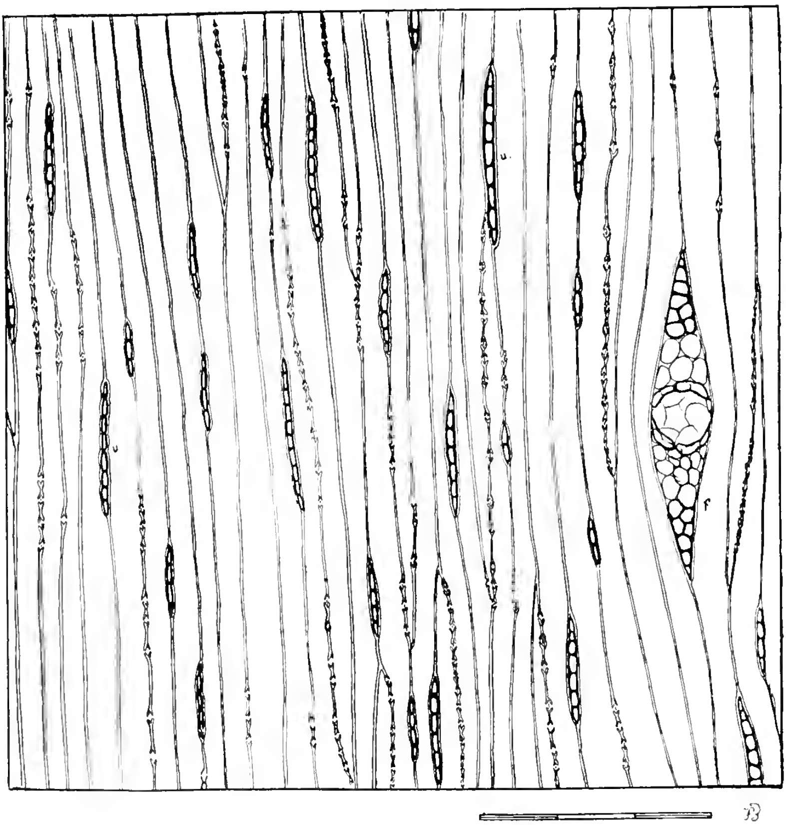

Fig. 1.

Fig. 1. Tangential view Pinus monticola, showing arrangement of the rays with reference to the tracheids.
f. fusiform ray with resin duct. u. uniseriate rays.

have, in addition to the above tissues, a third tissue designed for the secretion, conduction, and storage of resin. A very intimate connection of the rays with the vital activities of the wood may be inferred from the fact that the rays continue living for fifteen years or more, or probably as long as the wood performs

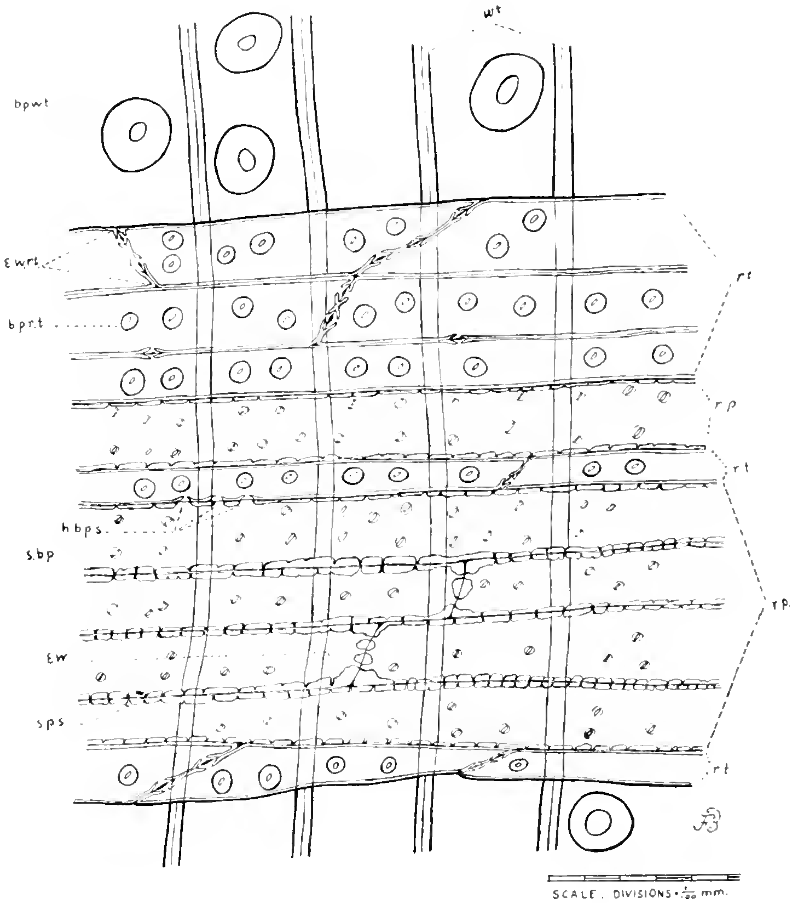

Fig. 2.

Fig. 2. Radial view of Picea canadensis, showing uniseriate medullary ray in section.

r. t. ray tracheids.
r. p. ray parenchyma.
w. t. wood tracheid.
e. w. r. t. end wall of ray tracheid, showing bordered pits in section.
e. w. end wall of ray parenchyma cells with simple pits in section.
s. p. s. simple pits in section.
h. b. p. s. half bordered pits in section.
b. p. w. t. bordered pit of wood tracheid.
b. p. r. t. bordered pit of ray tracheid.
s. b. p. semi-bordered pit of ray parenchyma.

its physiological functions, and are so disposed that, so far as it has been possible to observe, *they come in contact with each individual tracheid of the wood.* It is not uncommon to find tracheids which show four or five points of contact with the ray system. The ray system, is, in turn, through the direct contact of each of its component rays with the cambium and the phloem, in communication with the leaves and all other living structures throughout the tree.

The ray pits formed at the point of contact of the storage cells with the wood tracheids exhibit a number of variations which seem to be related to the life conditions of the species. Unlike the tracheid pits, they differ widely in shape, size, and number for the different genera and species of conifers, affording both generic and specific points of distinction of high taxonomic value. In Larix and Picea, however, these constant characters are similar, especially in P. sitchensis and L. occidentalis, where the ray characters are insufficient to separate the two genera. For this reason, together with the fact that the two genera have widely different habits of nutrition, the two genera have been selected for comparison, since a more direct comparison of the variable characters is possible with woods similar in structure than where the problem would be complicated by structural differences.

In leaf habit, differences are at once apparent that are associated with differences in the storage of reserve and in other processes of nutrition of a fundamental character. The leaves of Larix remain through but one season; being a deciduous conifer, the entire foliage must be regenerated each year. In Picea, the leaves remain for 4-7 years, or the spruce is only ¼ to 1/7 deciduous, and needs to regenerate ¼ or less of its foliage each year. Larix, as with other deciduous trees,[4] is totally dependent upon reserve food for the regeneration of its leaves. Such reserve is stored in the ray system and a heavy demand will therefore be made upon the rays early in the season. Picea, on the other hand, could probably meet this need partly, if not wholly, by the newly formed products of assimilation, since it has been found that first, second, and third year leaves of conifers begin to form starch by the middle of March, even when the temperature often falls below 0° C.[5] Picea, then, should make a relatively slight demand, early in the season, upon the stored reserve.

To determine the relative difference in the amount of starch stored by Larix and Picea, trees of Larix decidua and Picea excelsa ten inches in diameter and growing on the Ohio State University Campus, were felled during winter and the volume of starch

4. Lutz. 1897. Büsgen's Bau und Leben unserer Waldbäume, p. 196.

5. Mer. 1885. Ueber eine Methode zur Beobachtung der Assimilation. Landwirtschaftl. Jahrb.

contained in the storage tissue of the rays estimated from planimeter measurements of projected drawings. In all cases Picea showed little or no starch in its woody tissues, while Larix contained starch in all of its corresponding living parts. The highest relative amount of starch was found in the dwarf branches where

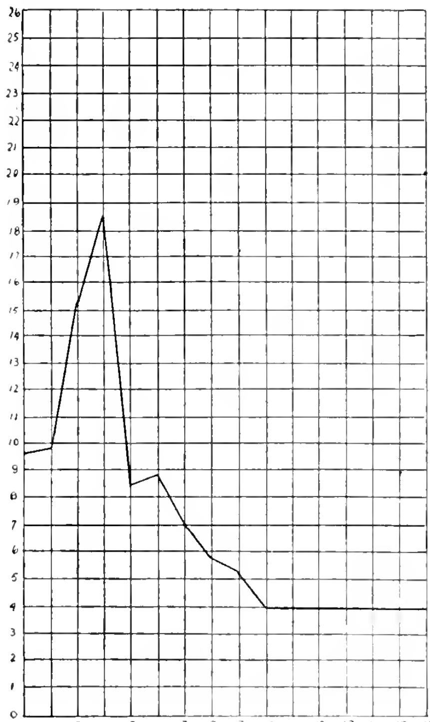

Fig. 3.

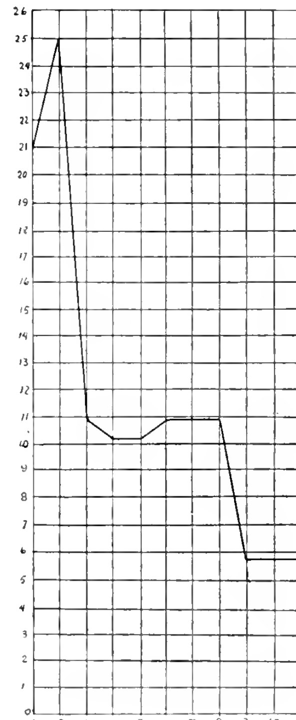

Fig. 4.

Fig. 3. Curve showing variation in size of ray pits of Larix occidentalis, through one annual ring of 16 tracheids, commencing with earliest formed tracheid of spring wood and ending with last formed tracheid of summer wood. Vertical scale, diameters squared.

Fig. 4. Curve showing variation in size of ray pits of Larix laricina, through one annual ring of 11 tracheids, on same scale as Fig. 3.

the rays were stored to their full capacity, but varying amounts of starch were found in all other portions where the wood was living. Rays of the sapwood zone, which was fifteen rings in width in the lower portion of the trunk, contained starch throughout the width of the zone. In some portions, 2% of the volume of sapwood was starch, though the rays in this portion of the tree

were not, as a rule, filled to this extent; but, in general, it may be stated that the rays of Larix are, during winter, stored with starch through fifteen years of growth.

Such reserves have been found to be used for two main purposes, the production of leaves and of seed. In rare instances, a

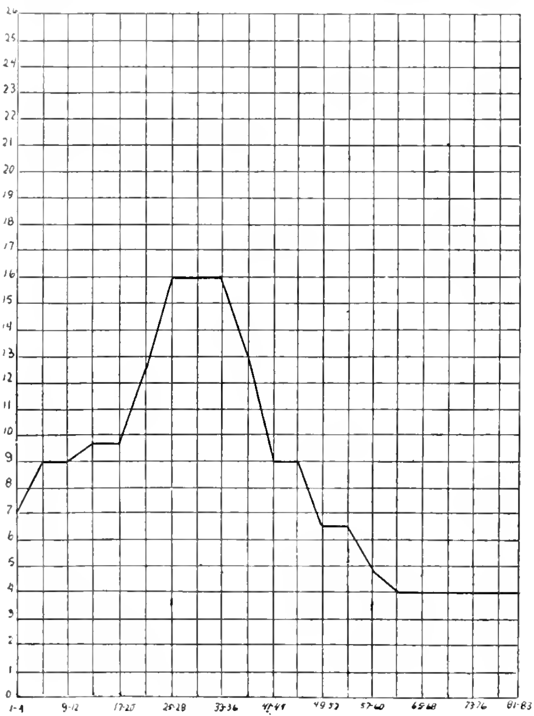

Fig. 5.

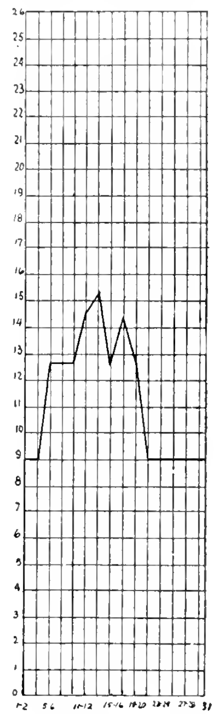

Fig. 6.

Fig. 5. Curve showing variation in size of ray pits of Picea sitchensis, through one annual ring of 83 tracheids, plotted on same scale as Larix, except that the horizontal scale of Larix is four times as great because of the fewer number of tracheids.

Fig. 6. Curve showing variation in size of ray pits of Picea canadensis, through one annual ring of 31 tracheids, on same scale as Fig. 5.

portion may be diverted to the growth of wood, but this is not usual. Use of the reserves for seed production will occur, as a rule, at periods of from two to several years; hence annual rigns will occur not subject to any modifications from this source. On the other hand, that used for the regeneration of leaves will be used yearly, and every annual ring will be subject to structural modifications by this factor.

It has been shown that the reserves stored in the rays are forced into the tracheids and are conveyed to the developing new shoots at the beginning of the growing season.[6] The yearly occurrence of this temporary current would be likely to influence the development of the semi-bordered pits through which it passes, providing such pits had not fully completed their development. Since a period of about 90 days is consumed in the development of an annual ring in Picea and Larix,[7] the ray pits of any given ring will be of successively greater age with the youngest at the commencement of the ring, in the earliest spring wood, and differing in age at the extremes by 90 days; hence certain of them, it may be assumed, would still be plastic when this current is formed. By way of confirmation, twigs of L. decidua were sectioned May 20, when leaves had apparently attained their full size. It was found that the sixth tracheid was then being formed, which would bear out the predicted sequence of the maturity of the ray pits, and be in proper position with respect to the greatly diminished current indicated by the fall of the curve. (Figs. 3 and 4).

The curves referred to were obtained from measurements taken of the diameter of the ray pits, commencing with the first spring tracheid and ending with the last summer wood tracheid. Such pits will, then, be arranged in series according to age. For sake of comparison, these measurements are squared, since the efficiency of circular osmotic membranes, other things being constant, should be proportional to such values. The accompanying curves plotted from the results so obtained, show graphically the existence of exactly such a variation in size as would be expected had the above outlined modifying influence of the assimilation current been manifest. As anticipated, both species of Larix show an early and strongly pronounced increase in the size of their ray pits corresponding to the probable time, intensity, and duration of the demand made upon the stored reserve, for the regeneration of leaves. Also, the curves of Picea show the expected absence of the early high point. The problem is here complicated by the presence of currents of newly formed assimilation products commencing in March and increasing with the advance of the season; but, in a general way, the shape of the curve is in accord with the probable influence exerted by the later leaf habit of the genus and the absence of growth conditions that would make the early and brief demand upon the stored reserve noted in Larix. The data thus collected has also demonstrated the intimate connection of the ray with the vital processes of growth and nutrition and the reaction of such processes upon the structure of the ray.

6. Fischer, Alfred. 1890. Pringsheim's Jahrbücher, XXII, p. 73.
Strasburger. 1891. Uber den Bau und die Verrichtung der Leitungsbahnen in den Pflanzen, pp. 98, 297.

7. Hartig, Robert. 1885. Holz der deutschen Nadelwaldbäume.

TABLE I.

Number of tracheid	Number of pits	Average Diameter in microns	Average Diameter squared
1	3	4.6	21.
2	6	5.	25.
3	7	3.3	10.9
4	1	3.2	10.2
5	3	3.2	10.2
6	6	3.3	10.9
7	6	3.3	10.9
8	3	3.3	10.9
9	5	2.4	5.8
10	2	2.4	5.8
11	3	2.4	5.8

Measurement of the ray pits of Larix laricina through one annual ring.

TABLE II.

Number of tracheid	Number of pits	Average Diameter in microns	Average Diameter squared
1	10	3.1	9.6
2	10	3.1	9.6
3	10	3.9	15.2
4	10	4.3	18.5
5	10	2.9	8.4
6	10	3.0	9.0
7	10	2.6	7.0
8	10	2.4	5.8
9	10	2.3	5.3
10	3	2.	4.
11	5	2.	4.
12	4	2.	4.
13	2	2.	4.
14	1	2.	4.
15	1		4.
16			4.

Measurement of ray pits of Larix occidentalis through one annual ring of 16 tracheids; 10-16, late wood; 15-16, so compressed that measurements were approximated.

TABLE III.

Number of tracheid	Number of pits	Average Diameter in microns	Average Diameter squared
1-4	7	2.6	6.8
5-8	12	3.	9.
9-12	13	3.	9.
13-16	11	3.1	9.6
17-20	12	3.1	9.6
21-24	12	3.5	12.3
25-28	12	4.	16.
29-32	12	4.	16.
33-36	10	4.	16.
37-40	12	3.3	10.9
41-44	5	3.	9.
45-48	4	3.	9.
49-52	4	2.5	6.3
53-56	4	2.5	6.3
57-60	4	2.2	4.8
61-64	4	2.	4.
65-68	4	2.	4.
69-72	4	2.	4.
73-76	4	2.	4.
77-80	4	2.	4.
81-83	4	2.	4.

Measurement of ray pits of Picea sitchensis, through one annual ring of 83 tracheids.

TABLE IV.

Number of tracheid	Number of pits	Average Diameter in microns	Average Diameter squared
1-2	5	3.	9.
3-4	5	3.	9.
5-6	6	3.5	12.5
7-8	7	3.5	12.5
9-10	8	3.5	12.5
11-12	7	3.8	14.4
13-14	6	3.9	15.2
15-16	5	3.5	12.3
17-18	7	3.8	14.4
19-20	5	3.5	12.5
21-22	2	3.	9.
23-24	5	3.	9.
25-26	4	3.	9.
27-28	5	3.	9.
29-30	4	3.	9.
31	2	3.	9.

Measurement of ray pits of one annual ring of Picea canadensis with 31 tracheids.

ROOT-KNOT OR EELWORM ATTACKS NEW HOSTS*

LEO E. MELCHERS.

In addition to the hosts known to be attacked by **Heterodera radicicola,** peculiar circumstances recently made it possible for the writer to note and observe its occurrence on seven new and unreported hosts.

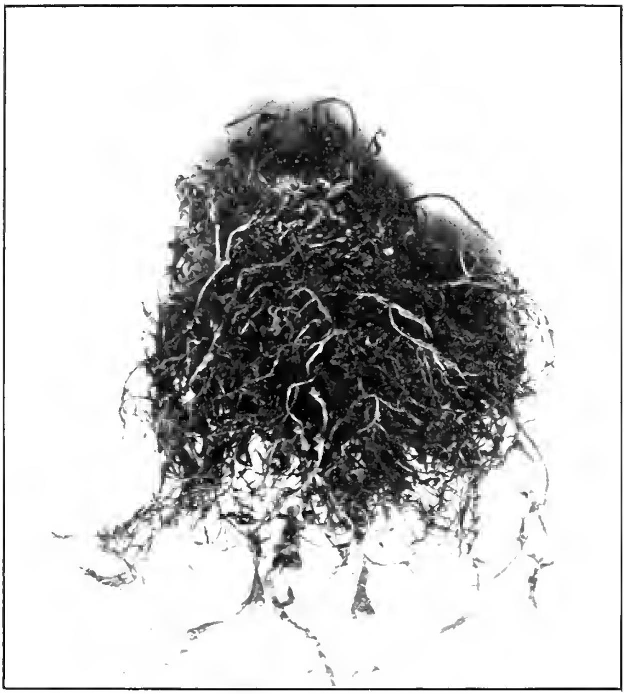

Fig. 1. Root-knot of parsley.
Two-thirds natural size.
Photo by L. E. Melchers.

During December, 1913, the writer noticed the first indications of the root-knot on the tomato crop which was being grown in one of the greenhouses belonging to the Department of Horticulture of the Kansas State Agricultural College. By the end of April the tomato plants were removed on account of their unproductiveness, due to the eelworm infestation. The roots of these plants

* Kansas State Agricultural College, Manhattan, Kansas.

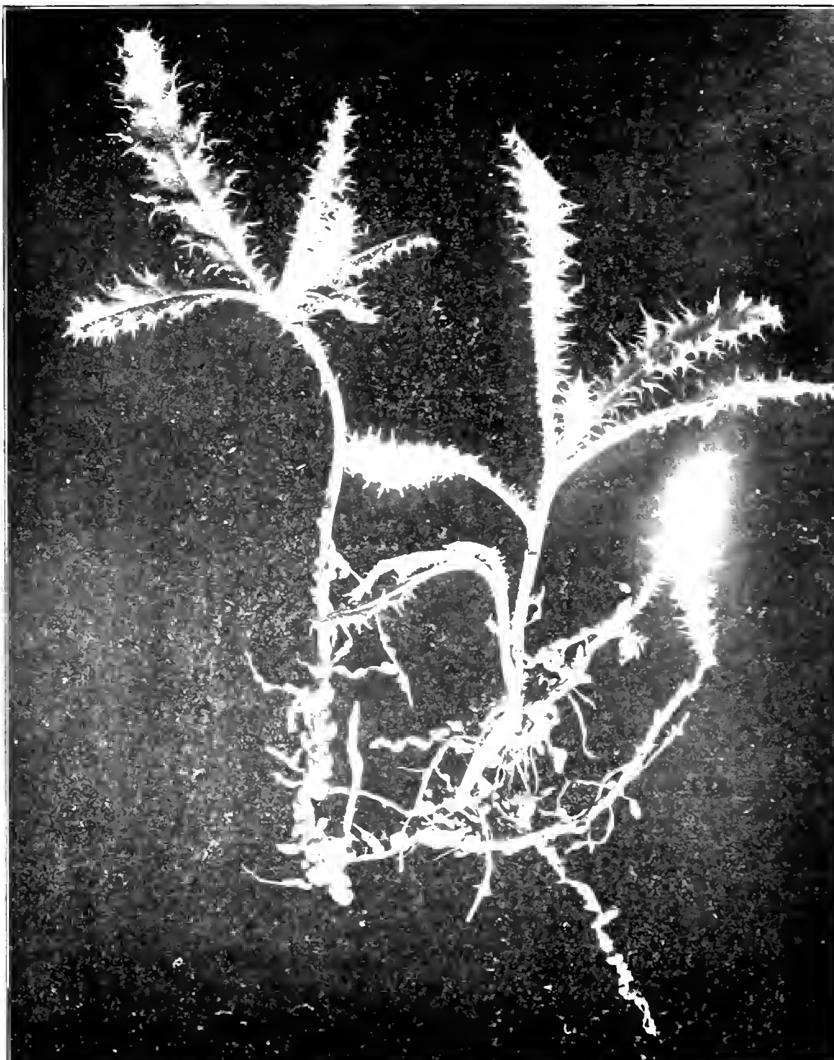

Fig. 2. Root-knot of Canada thistle.
Two-thirds natural size.
Photo by L. E. Melchers.

for the most part had decayed, liberating the eggs and egg-filled bodies of the female nematodes into the soil. The tops of the tomato plants and as many of the remaining roots as could be found, were removed from the bench. The soil itself, however, was not given a soil treatment, but was allowed to remain in an infested state.

The foreman in charge of the greenhouses gave directions to place various potted bedding plants on top of this bench, allowing the pots to come in direct contact with the soil which had previously grown the infested tomato crop. The experiment proved an interesting one, for among the potted plants there were a number which became infested, while, on the other hand, a few kinds which were under the same environmental conditions proved non-susceptible to an attack.

After having stood on top of this bench for more than a month, the following plants showed the development of nodules upon their roots, and upon a microscopic examination revealed the egg-filled nematodes of **Heterodera radicicola: Vinca rosea Linn.** (Madagascar Periwinkle), **Chrysanthemum frutescens Linn.** (Marguerite), **Celosia empress** (Cockscomb), **Matthiola incana Var. annua Voss.** (Ten-weeks or Intermediate stocks), **Zeæ mayz** (Burbank's Rainbow Corn), and **Phlox** (Phlox annual). The writer also reported **Cirsium arvense** (Canada thistle), a susceptible host (Science, 40::241, 1914). There were also a large number of other plants whuch were attacked, but only those which proved to be new hosts have been listed here.

The eelworm has been previously reported as attacking **Zeæ mayz** by Neal, B. P. I. (1889), Burbank's Rainbow corn being a horticultural variety of **Zeæ mayz.**

The following is a list of potted plants which remained apparently unaffected, although they were growing among the infested potted plants: **Centaurea imperialis** (Royal Sweet Sultan), **Calundula** (Pot marigold, Vaughan's Mammoth Mixture and Eldorado), **Salvia zurich** (Dwarf Sage), and **Canna** varieties.

The soil which was used in the bench was originally obtained from a nearby orchard, and was probably infested with **Heterodera radicicola** at the time that it was placed in the greenhouse bench, although it is possible, but not probable, that the organisms gained entrance through the application of infested manure; knowing the source of the fertilizer used, this did not appear to be the case. The soils in many sections of Kansas are badly infested with the eelworm, and the problem of economically combating this pest is becoming a serious problem, especially in the truck-growing regions where entire crops become affected.

Besides the above hosts, the writer obtained specimens of **Carum petroselinum** (parsley) from Hutchinson, Kansas, which

were badly affected with the nematode; this is likewise an unreported host. The plants were growing out in the open field at the time the injury was observed. It is not definitely known whether these plants became infected from nematodes which remained alive in the field over winter, or whether contamination resulted otherwise.

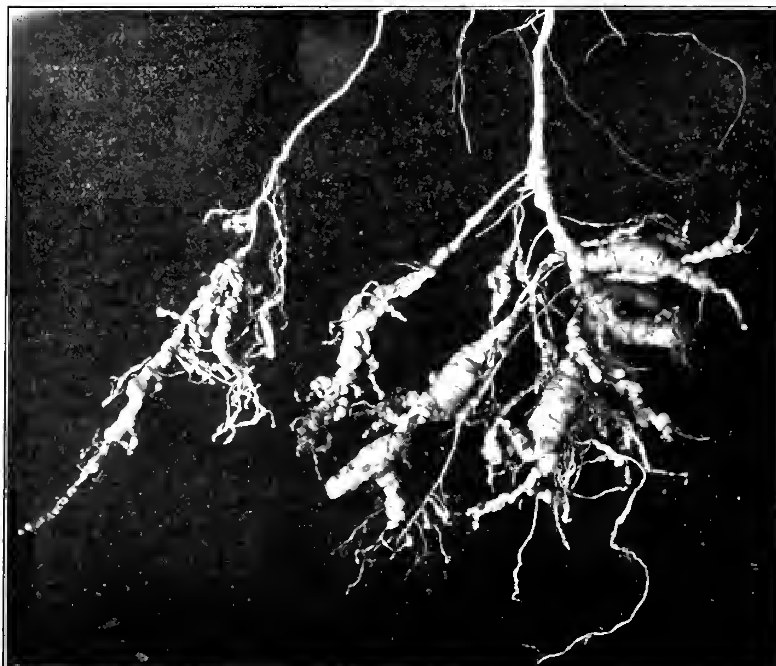

Fig. 3. Root-knot as it occurs on tomato.
Two-thirds natural size.
Photo by L. E. Melchers.

Apparently climatic conditions in this region cannot be too stringently depended upon as a means of control in holding the eelworm in check in the open fields. The winters vary in severity, and are not always severe enough to eradicate the pest in badly infested soils.

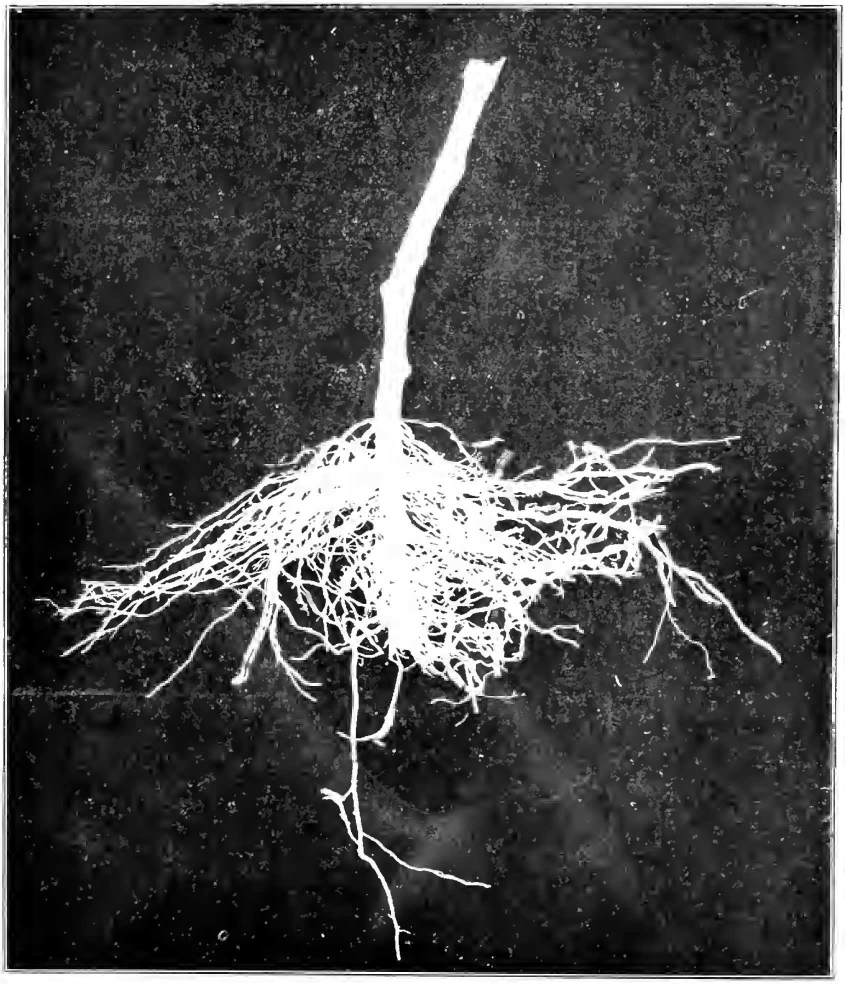

Fig. 4. Normal tomato root for comparison.
Two-thirds natural size.
Photo by L. E. Melchers.

MEETINGS OF THE BIOLOGICAL CLUB.

Botany and Zoology Bldg., Jan 11, 1915.

The meeting was called to order by the President, Dr. Seymour, and the minutes of the previous meeting were read and approved.

Messrs. H. D. Chase, Vernon Haber, R. C. Smith, F. H. Smith, J. R. Smith, W. T. Owry, W. S. Krout, H. J. Reinhard, D. D. Leyda, W. E. Laughlin, C. W. Hauck, John Eckert, Oliver Gossard, J. R. Stear, R. C. Baker, R. A. Knouff, E. H. Baxter, F. F. Searle, Harry Cutler, and Adolph Waller were elected to membership in the club.

The names of Messrs. Joel Foote and A. H. Smith were proposed for membership in the club.

Prof. Osborn gave a brief report of the meeting of the American Association for the Advancement of Science at Philadelphia during the Christmas vacation, and stated that the next meeting of the association would be held at Columbus. He suggested that a committee be appointed by the club to assist the different committees of the University in the preparations for the entertainment of the association. It was moved by Dr. Krecker and seconded by Mr. Kostir "that the President appoint such a committee before the next meeting." The motion was carried.

The program for the evening consisted of many interesting reports from the different members who had attended the meeting at Philadelphia: Professors Schaffner, Griggs, and Stover gave reports from the Botanical sessions; Professors Osborn and Krecker from the Zoological and Entomological sessions; Mr. Weiss from Psychological session; Prof. Prosser from the Paleontological and Geological sessions.

The club then adjourned.

Botany and Zoology Hall, Feb. 8, 1915.

The meeting was called to order by the President, Dr. Seymour, and the minutes of the previous meeting were read and approved. The attendance was unusually large, two hundred and forty-three being present.

Messrs. Joel Foote and A. H. Smith were elected to membership in the club. The names of Messrs. H. C. Yingling, G. S. Zink, and W. D. Will were proposed for membership.

The President appointed Professors T. M. Hills, F. H. Krecker and R. F. Griggs to assist the different committees of the University in the preparations for the entertainment of the American

Association for the Advancement of Science which will meet in Columbus during the next Christmas vacation. It was moved by Prof. Landacre that the President announce the time for the next meeting of the club. The motion was carried. The time for the next meeting was set for the second Monday evening in March.

The program for the evening consisted of a very interesting address on "Evolution and Death" given by Prof. L. B. Walton, of Kenyon College. A brief discussion of the views of Darwin, DeVries, Johannsen, and Lloyd were given. The speaker examined two hundred daisies from a fertile soil, also the same number from poor soil, and the coefficient of variation was found to be the same. Close breeding is more variable than cross breeding and sexes arose as an effort in nature to hold variation in check. Cells are smaller in cross breeding than close breeding; small cells produce faster and, hence, a larger organism. Prof. Walton's hypothesis to account for death was that the cells of an adult organism, being the result of very numerous cell divisions (and hence asexual generations) finally become so highly variable that sooner or later some one or more cells located in a vital part will not be able to subserve their intended function, causing the death of the entire organism. As a working hypothesis, variations were divided into normations and abnormations; the former into fluctuations, amphimutations, and cumulations; the latter into monstrositations, defactorations, and fractionations.

After a discussion of the address, the club adjourned.

Botany and Zoology Hall, March 8, 1915.

The meeting was called to order by the President Dr. Seymour, and the minutes of the previous meeting were read and approved as read. Messrs. H. C. Yingling, W. D. Will, and G. S. Zink were elected to membership.

It was moved by Prof. Hine and seconded that the President appoint a committee of three to consider the advisability of making the Biological Club one of the sections of a Science Club to be formed in the University; also, to consider turning over the Ohio Naturalist and Journal of Science to this Club, providing sufficient financial support be insured for its publication; the name of the Ohio Naturalist and Journal of Science to be changed to the Ohio Journal of Science. The motion was carried. Mr. Shadle called attention to the fact that many of the trees had been removed from the campus during the last few years and only a few had been replanted during this time. It was moved by Mr. Shadle and seconded that a committee of three be appointed by the President to see what could be done towards having more trees

replanted on the campus this spring. The motion was carried. Professors Osborn, Prosser, and Durrant were appointed on the first committee and Mr. Shadle, Prof. Lazenby, and Mr. Forest Brown on the latter one.

The program for the evening consisted of two very interesting papers: "The Phylogenetic Relationship of Man and Lower Animals," by Mr. Rollo C. Baker; "The Psychological Relationship of Man and Lower Animals," by Prof. Weiss. Mr. Baker compared the Paleontological, embryological, physiological, and structural development between man and Anthropoid apes. Prof. Weiss compared the actions of lower animals with man. The speech reaction gives man the power to reproduce things of the past and to consider the future, while other animals can adjust themselves only to the present. The speech reaction can be converted into writing and thus man has the traditions and experience of past generations to guide his actions.

After a discussion of the papers, the Club adjourned.

CARL J. DRAKE, *Secretary.*

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